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AGRICULTURAL ENGINEERING

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Some Postwar Opportunities in Agricultural Engineering *R. H. Driftmier*

Machines and Equipment for Producing Sweet Potatoes *O. A. Brown, W. S. Anderson*

What Needs to be Known in the Planning of Farm Ponds? *D. B. Krimgold*

A Review of Thirty Years of Developments in Terrace Spacing *C. E. Ramser*

How a Nomograph Simplifies Gin Fan Power Calculations *A. J. Johnson*

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

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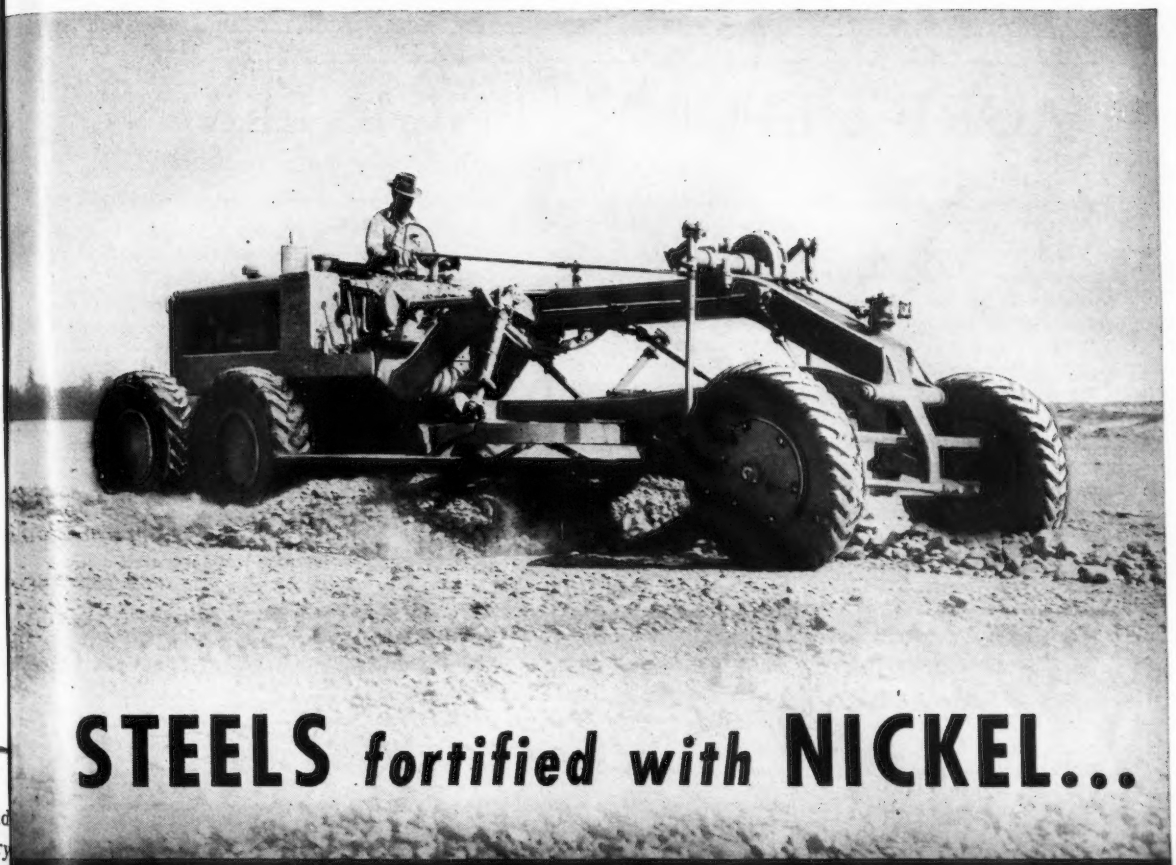

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AGRICULTURAL ENGINEERING

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EDITORIAL

President Points a Way

AMONG the minor tragedies of the war economy is the fact that so few members of the American Society of Agricultural Engineers could be present in person to hear the annual address of retiring president R. H. Driftmier. Though it cannot convey the warmth of his genial nature and scholarly temperament, its publication as the leading article in this issue does set forth his message in a fashion as comprehensible as it is comprehensive. We commend its careful reading not only as a succinct summary of the state of the profession, but for the perspicacity with which it peers into the problems and promise of the postwar future.

We are impressed with the emphasis he puts on the proposition that parity of prices cannot bring parity of income. While good prices may improve the relation of farmers to non-farm people as a whole, poor farmers will continue to be poor farmers, only a little less poor. They never can catch up with their fellow farmers except by expanding their productive capacity. Their level of living and education never can come up to par otherwise, unless we pamper and pauperize them with subsidies for service not rendered. We doubt that a pauperized peasantry is in keeping with the principles whereby the world's youngest nation became its greatest.

Professor Driftmier urges that rural industry be developed and promoted as a source of supplemental employment and income. For farmers whose acreage and soil fertility are so meager as to set a low ceiling on their possible production, it holds much promise. Yet that promise cannot be realized if their farming methods remain so primitive as to occupy their time and leave little or none for participation in rural industry. We dare not blink the fact that low acreage and low productivity per man are the result, more than the cause, of inefficient farming methods.

Rural industry, therefore, appears as only a supplement, not a substitute, for modern management and machinery that will bring farm production per man-hour up to par. It is only an alternative to adequate acreage. Whichever alternative we choose, it can come to fruition only by methods which enhance man-hour productivity. We believe that both alternatives should be pursued with all vigor. Both are full of work for agricultural engineers.

Whither Education?

ANOTHER point we choose to emphasize in the Driftmier presidential address may be introduced in his observation that "many of our educational leaders have been and still are opportunists who have lost sight of their educational ideals in their misplaced zeal to keep open to all comers the wide doors of their institutions."

A few lines further he outlines four objectives to be sought in agricultural engineering education. The first three are purely, or mainly, occupational in purpose. Up to that point there is no difference in direction, though there is in level, from that of the trade school or the barber college. Then, in what we would regard as the climactic position he offers as the final objective "to supply training in those humanistic and general subjects intended to develop a breadth of interest and an appreciation of the responsibilities of citizenship."

It might well be argued that only as it conforms to this fourth objective can an engineering course be properly regarded as education. No doubt the paucity of such subject matter in the training and thinking of too many engineers accounts for the indulgent disdain with which they are regarded by devotees of the liberal arts. It seems a pity, when the intellectual caliber required, and the precise putational patterns acquired, can so well implement a cultural content in the education of the engineer.

When educators themselves sometimes lose sight of this fourth objective we can hardly expect candidates for college to have its vision and come clamoring for its inclusion in the courses they contemplate. Neither is its value likely to loom large in the thinking of their elders, however wise and successful, if they themselves never shared in higher education. It is a job for leadership, even salesmanship, by engineers and other college people who can vouch for educational values in terms of personal experience.

Tractors Outwear Farmers

A TWILIGHT drive of a hundred miles in the northern corn belt, where farmers were still working to catch up with wet-weather weeds and a late season, revealed a large number of them standing rather than sitting on their tractors. Mentioning this to a farm family at destination brought a remark from the daughter that her father "*always* stood up to run the tractor."

The mother added that in most of the families of their acquaintance, and in their age bracket, the men regularly stood at tractor work, while younger farmers usually used the tractor seat at least part of the time. The father explained that when he was younger he could ride the tractor when seated, but in recent years found that he could not "take it." His age was in the early fifties.

He might well serve as a guinea pig, not only because he is a typical farmer in average health, but more especially because he has used the same tractor, kept in condition by repeated rebuilding, for 23 years. This seems to indicate that the change is in the man, not in the machine. He says he "just can't stand the vibration any more." To the daughter's suggestion that a rubber-tired tractor would be better he replied that the bouncing would merely make things that much worse. Moreover, most of the standees first mentioned were riding on rubber.

Though it was implied that the trouble comes primarily from "road" shocks, it could well be that engine vibration contributes its component. Discussion did not go into anatomical and physiological detail. It deserves study to determine the nature of change in the tractor operator with advancing age, whether a normal loss of resilience or a cumulative damage due to years of jolting. Probably a medical study should precede the engineering attack which seems long overdue on this problem.

A look at the average-age figures for farmers, for a period of years past and with due regard for the gradual increase in average age, indicates that this is no temporary nor minority problem. If we cannot put shock absorbers between the tractor and the earth, we must put them between the tractor and the operator. Apparently there must be more than the present glorified sack of oats on a mildly modified mower seat. We still face the job (to paraphrase Professor G. W. McCuen's classic utterance) of converting the tractor seat from a liability into the antithesis thereof.

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AGRICULTURAL ENGINEERING

Vol. 26 JULY, 1945 No. 7

Postwar Opportunities in Agricultural Engineering

By R. H. Driftmier
FELLOW A.S.A.E.

R. H. DRIFTMIER
President, A.S.A.E., 1944-45

DICKENS, in the "Tale of Two Cities", describes the state of mind of the people of France on the eve of the Revolution. "It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of light, it was the season of darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we were all going direct to heaven, we were all going direct the other way, ——". All of you, I am sure, have at one time or another in the last few years experienced this same feeling of uncertainty and confusion, a feeling brought about by words and writings without reality in the world as it actually is. The postwar era, with all of its tragic spiritual and physical needs, cannot be approached by such unrealistic thinking. In the postwar period it is inevitable that business, industry, and agriculture, the great providers of employment for the American people, will be extended and expanded. Is there any greater challenge or duty, either today or tomorrow, which faces the Agricultural Engineer than to aid in the reconversion of these economic forces to a peacetime basis? Whatever we intend to do we must begin doing now. While we plan for the future there are areas of opportunity and obligation that we cannot afford to overlook.

Thorough planning is of course necessary to the successful solution of our problems. But plans and action are part of one responsibility. Plans and objectives in themselves mean little—only when realized do they assume significance. Their effectiveness is measured only in terms of results. We hear a great deal these days about postwar plans. No one knows how many planning agencies are in existence today. Some are good—some are bad; they range all the way from the field of practical realities to that of Utopian forecasting. We need to direct our thinking toward real problems and actual objectives.

Now let us consider a type of personal planning with which we are all familiar. There is no difference, broadly speaking, between December 31 and January 1; yet tradition and custom have drawn an imaginary line between them. On one side of this line we place a vanished year with its successes and failures, its things done and things left undone, its achieved ambitions and unrealized dreams, its satisfactions and disappointments, its gain and losses, its good and bad. On the other side we envision a year to come with all that hope and desire may bring out of it. And we gird ourselves with fresh resolution and renew our courage and set our faces forward with that undying cheerfulness which is at once our inspiration and our salvation. We call this stocktaking and planning, the making of New Year's resolutions, and we blithely follow the habit even though most resolutions are little more than a memory before the first month has passed. Why? Because we have laid before ourselves too ambitious a program. Instead of making one basic resolution or plan which might cover, more or less, a number of other plans deemed desirable, and instead of planning and directing our thought and conduct in a general way we seek to meet each individual phase of our problem, and soon we cannot see the forest for the trees. We fail in one purpose; and, having failed, we lose heart and weaken our power to pursue the others.

Personal experience should teach us that in our planning we must first of all determine clearly our objectives. As agricultural engineers, what is our purpose? For what are we striving? From a professional standpoint our Society constitution and by-laws answer this question clearly and concisely: "The objects of the Society are to promote the science and art of engineering in agriculture; to encourage original research; to foster agricultural engineering education; to advance the standards of agricultural engineering; to promote the intercourse of agricultural engineers among themselves and with allied technologists; to encourage the professional development of its members; and severally and in cooperation with other groups to broaden the usefulness of agricultural engineering." I wish that every member of the Society would at least *read* this statement; then, having read it, let it be his creed and guide in the conduct of his professional duties. It is basic, it is fundamental, it is comprehensive. It offers us a plan in our approach to the problems before us.

But, first, what are some of the specific problems that will face us in the postwar period? There are many: some are immediate; some will extend over a period of years. Although the entire problem of agricultural planning is now vastly complicated by war, and although the list of changes in agriculture is a long one, there is nothing basically new about agricultural production or distribution except improved techniques in the more effective use of the principle of organization of capital, labor, materials, facilities, and methods. It is our responsibility as professional engineers to determine, recommend, apply, and promote the best solutions of engineering problems in agriculture, and through modern equipment, materials, facilities, and practices to help bring about the ultimate objective of better production and distribution methods, increased efficiency, lower costs, and assured profits. Our best consideration might well be given to the expanding engineering opportunities in the fields of farm machinery and equipment, farm structures, rural electrification, soil conservation, food processing, and rural industries.

The development and adaptation of mechanical farm equipment, especially that which can be used with profit on family-size farming units, and a greater efficiency in the use of farm power are essential to the best use of farm land. Special efforts should be directed toward the further development of tillage methods and equipment to reduce the costs of power and labor to a minimum commensurate with good crop production. Additional studies and further development of precision planting equipment are needed. New problems in the harvesting of various crops continue to arise not only in connection with the economical adaptation of available machinery, but also in the necessity to develop new harvesting principles to meet special problems and conditions. There is need for further study of the coordination of the periods of planting, cultivating, and harvesting with periods of abundant rainfall. Further and more complete mechanization in crop production is inevitable. But the employment provided by enlarged rural indus-

Annual address of the President of the American Society of Agricultural Engineers, before the A.S.A.E. Annual Dinner at Chicago, Illinois, June 5, 1945.

R. H. DRIFTMIER is head, agricultural engineering department, and head, plant operations department, University of Georgia, and supervising engineer, University System of Georgia.

tries will help to alleviate the labor problem resulting from a more extended use of mechanical power.

There is need for studies to determine the specific agricultural and environmental requirements of farm structures and their economic limitations. The appraised value, condition, and quality of farm buildings has declined steadily during the last decade. Changes in agriculture, new materials, prefabrication, and improvements in heating, lighting, refrigeration, and household equipment have a bearing on the design and utilization of farm structures. The trend toward community and cooperative enterprises affords an opportunity for rendering a distinct service to agriculture in the design of community markets, sales pavilions, food-processing plants, frozen food locker plants, meat-curing plants, creameries, and a long list of other similar structures. This will mean giving in our professional curriculums greater emphasis to structural design and greater consideration to the fundamental laws of thermodynamics and the applications of those laws to refrigeration, heating, ventilation, and air conditioning.

It is generally recognized that the success of the whole rural electrification program depends upon the extent to which the farmer and his family utilize the service in the home and in farm production. In addition to increasing the use of available electric equipment new and better adapted kinds of equipment are needed. New types of appliances and machines will ease the burdens of housekeeping. Home freezer units, refrigerators of new design, new applications of infrared rays and of germicidal lamps, electronics, radar, midget motors, plastics, and many other items developed for military use must be studied and adapted to the production of agricultural revenue. In the postwar period when restricted materials become available, electric lines will be extended to practically every rural home in America. It is our responsibility to insure the best possible utilization of this vast source of energy so that it may be a heartening influence in enhancing the well-being of those it serves.

A GENERAL AGRICULTURAL ENGINEERING OBJECTIVE IS TO DEVELOP A SOUND SYSTEM OF SOIL AND WATER CONSERVATION FOR FARMS

The general objective of the soil conservation program is to develop a sound system of soil and water conservation for the farms of the country. Such a program will include the determination, evaluation, and elimination of the erosion hazards of various cropping methods; the determination of the effectiveness of different grasses and associated plants in conserving soil and water; the study of the relation of the hydrology of soil and water conservation to erosion control and water-conserving practices and flood control on agricultural lands; the determination of the most efficient and beneficial methods of storage, distribution, and application of irrigation water; and the need and design of drainage systems, efficiency of various methods, and the evaluation of agricultural drainage as related to soil conditions.

The processing of farm products includes a vast group of engineering problems requiring solution. These problems involve the application of engineering methods, equipment, and machinery to the processing on the farm and in the community of various types of crops, fruits, vegetables, and animal and poultry products. Further studies are needed on the engineering aspects of pasteurization, dehydration, canning, milling, freezing, cleaning, storing, conveying, curing, and grading of all types of farm crops and products. Here again the Agricultural Engineer must lead the way in scientific and applied investigations that will make possible the more efficient and effective utilization of the potentialities of this all-important enterprise. Engineering developments such as these mean that in formulating a wise postwar development program our entire economy must be surveyed in the light of our resources and opportunities. Rural industry is one of our greatest and also the least developed of such resources.

Most of our states have postwar industrial development boards of one sort or another. Most of these committees have been concerned only with the development of large cities and big business. We should count on urban leadership to do its part. Yet our industrial economy should include small towns and rural communities. At the national level the goal of postwar planning is full-scale employment. The objective of employment for all members of the labor force is a high income, both total and per capita. In the society in which we live urban or non-farm incomes tend more and more to become equalized in all sections of the United States. Such equalization is brought about by national legislation, such as the wage and hour laws, other forms of federal control, and the activities of organized labor. But no national scheme has brought about equalization of farm income. Parity prices, yes; parity of income, no. This is something that cannot be brought about by acts of Congress. It can only be accomplished by changing our occupational pattern. Agriculture is changing. Rural life is changing. So rapidly have these changes come during the past ten years that we have not become adjusted to them—we have not taken full advantage of the opportunities they offer for creating jobs, increasing income, and adding to our conveniences and comfort. What are these opportunities, these developments that will add to wealth and income and raise our standards of living? Every crop and every animal enterprise demands marketing, processing, and distributing equipment and services. Rural industries include plants, business organizations, and services related to farming and rural life. If we are to raise living standards of rural people, make possible better farming practices, sell our own products to our own people, and provide employment for surplus labor, then facilities for marketing, processing, and manufacturing must be provided. According to studies made by Dr. Paul W. Chapman, dean of the college of agriculture at the University of Georgia, the full import of rural industries in our agricultural welfare are illustrated as follows:

"To raise living standards of farm peoples we need more community food preservation plants, freezer lockers, abattoirs, meat-curing plants, etc.

"To improve farming practices and reduce production costs we need seed-cleaning plants, feed-mixing plants, fence post treating plants, hatcheries, etc.

"To sell our own products to our own people we need canning plants, peanut butter plants, poultry-dressing plants, sweet potato curing and storage plants, market-grading and assembly centers, creameries, milk evaporation plants, and a long list of others.

"To provide employment for surplus labor, we need, in addition to facilities of previous types, big industry and little industry dealing with agricultural supplies such as feed, fertilizer, farm implements, packing equipment boxes, crates, and cases; also, industries processing farm products such as textiles, meat packing, oil mills, and wood-using industries."

In a booklet entitled, "New Rural Industries That Fit Your Community", published by "The Progressive Farmer", Dean Chapman lists 101 rural industries under four types of development: (1) Plants and equipment for processing farm products; (2) plants for making and services for distributing farm supplies; (3) buildings, equipment, and services for the efficient marketing of all farm products, and (4) farm and home service plants and equipment.

RURAL INDUSTRIES WILL DO MUCH TO SOLVE POSTWAR PROBLEMS OF UNEMPLOYMENT AND PARITY OF INCOME IN AGRICULTURE

Rural industries such as these will do much to solve our postwar problems of unemployment and parity of income in agriculture. They present a challenge to the Agricultural Engineer. It will be our task and our duty to provide, in cooperation with other scientists, the scientific and engineering information and guidance necessary to success. In considering rural industries we must temper our enthusiasm with facts. A careful analysis should allow us readily to determine whether a given industry has a functional relation to the social, economic, and agricultural situation in the community. A properly located industry should fit socially as well as technically. We must not only analyze the elements of production and marketing costs, but we must know our people, their customs, habits, traditions. And to give us this knowledge we must look to American education.

Being neither a prophet nor the seventh son of a prophet I cannot foretell the future of education in this country. Perhaps, with the help of others, I can indicate in a general way some of the accepted objectives of our educational programs, and some of the problems that confront us. Of one thing I am sure, and that is that an educational program founded on expediency is as unstable as a building constructed on shifting sands. Unfortunately many of our educational leaders have been and still are opportunists who have lost sight of their educational ideals in their misplaced zeal to keep open to all comers the wide doors of their institutions.

Although the American university can learn much from the training programs of industry, the Army, and the Navy, we must remember that the objectives are not the same. The university on the one hand is preparing its students for a broad field of service whose worth cannot be fully measured until several years have elapsed, whereas industry, the Army, and the Navy desire a system of education which will, at the end of three months, six months, or at the most one or two years, produce a type of person who will accomplish a specific goal or be fitted for a particular type of service.

The Committee on Engineering Education After the War of the Society for the Promotion of Engineering Education states: "The purposes and problems of engineering education hinge on its two major responsibilities. One of these, which determines its aims and standards, is to the public, industry, and the profession it serves. The other, which determines its methods, is to the students as individuals." The specific purposes implied are broad in scope and as applied to agricultural engineering, suggest the following objectives:

1 To afford training in science and in the foundation engineering subjects proven by experience as essential for any sound engineering curriculum.

2 To give such training in applied soil, plant, and animal science as will insure an understanding of and a sympathy for the problems of agriculture.

3 To provide instruction in the special fields of engineering related to agriculture.

4 To supply training in those humanistic and general subjects intended to develop a breadth of interest and an appreciation of the responsibilities of citizenship.

At present there is no unanimity among agricultural engineering educators upon specific course or subject-matter content of a curriculum embodying such purposes and objectives. Such a curriculum has been prepared by the Committee on Curriculums of the American Society of Agricultural Engineers. It or one of such character as to merit full accreditation by the E.C.P.D. should be adopted by those departments of agricultural engineering desiring to offer a professional course to train (1) those who would follow an engineering program of the usual pattern, (2) those preparing for careers in the operation and management of industry, and (3) those who would be fitted for unusual scientific and creative accomplishments.

It is apparent that educational efforts should be broad enough in scope to include service courses for all professional fields related to the industry of agriculture. The report of the Subcommittee on Agricultural Teacher Training, Committee on Curriculums (College Division) of the American Society of Agricultural Engineers, issued in 1944, stresses the importance of agricultural engineering in the training of teachers of vocational agriculture. And since vocational education has made tremendous strides in the last decade, the engineering aspects of vocational training are no longer just "farm shop". They include power and machinery, farm structures and related facilities, rural electrification, soil and water conservation, irrigation, drainage, food processing. The war period has increased the responsibilities and demands made upon teachers of vocational agriculture, county and home demonstration agents, and other technicians concerned with the welfare of agriculture. Agricultural engineers have a definite responsibility to those groups in providing well-taught courses in farm shop, rural electrification, dairy engineering, heating, refrigeration, drainage, irrigation, applied hydraulics, conservation practices, and similar applied courses.

A MAJOR RESPONSIBILITY, AND OPPORTUNITY, CONFRONTING THOSE CONCERNED WITH AGRICULTURAL-ENGINEERING EDUCATION IS THAT OF TRAINING WAR VETERANS

I need not stress here the importance of short courses, conferences, and demonstrations and the opportunities that they offer to soil conservation technicians, building materials dealers, country carpenters and contractors, tractor and machinery operators, mechanics, locker plant operators, food processing plant technicians, homemakers, and others concerned with agricultural problems.

A major opportunity confronting those concerned with education, whether in college or university, in industry, in the Army or the Navy, is that of training veterans. Such training may include the professional degree course, non-credit short courses, and service courses for other departments. Furthermore, universal military service may bring new problems and adjustments. Still another area of service is in providing training for young engineers from foreign countries. Since any rehabilitation program in devastated areas will be concerned with agriculture, it is quite evident that the agricultural engineer will play an important role in such a program.

The preceding discussions have dealt largely with training programs for those who wish to continue or extend their education. I now wish to suggest a program of "refresher courses" for those veterans who either entered the service immediately following graduation or have had such extended periods of military service that they want to be brought up-to-date on what has happened in their field of specialization. To me, such a series of refresher courses will serve two purposes: first, to acquaint the returning service man with new developments and needs in his field, and second, to familiarize those of us who have been on the home front with scientific developments used by our armed forces. Perhaps we should add a third purpose, namely, to orient the civilian mind to the thinking of the veteran. To me that is even more important than the converse. To be specific, I wish to recommend that the American Society of Agricultural Engineers sponsor and conduct a series of four or more refresher courses of one week to ten days' duration at strategic places in each of our major fields. For example, a course in farm structures and utilities might be held at the University of Illinois, one on irrigation at the University of California, one on power and machinery at Iowa State College, rural electrification at Virginia Polytechnic Institute, food processing at the University of Georgia. At each of these institutions the instructional staff for these short courses would be made up of the best authorities in the particular field regardless of their occupational or professional affiliation. The conference on barn hay curing sponsored by the Southeast Section of the A.S.A.E. and held at Knoxville, Tenn., was conducted on this principle and attracted nationwide attendance. It did more to clarify our thinking on barn hay curing than a dozen state meetings could have done.

WHILE PAYING TRIBUTE TO YOUNG AMERICANS RETURNING FROM WAR SERVICE, AGRICULTURAL ENGINEERS WILL NOT LIGHTLY DISMISS THEIR RESPONSIBILITY

"This Is Your America". This caption headed an advertisement in one of our southern papers a few days ago. Below the caption appeared these words addressed to the youth of America: "To you we pass the torch! Your lives will shape the destiny of days to come. The task of planning an Eternal Peace, of rebuilding a World where all men are free and equal in their Pursuit of Happiness — these, too, are yours! To you we say — Here are our Ideals — our Courage, our Integrity, our Hopes. Here is your future — your America — your World! We Believe In You!"

A beautiful expression of our faith and trust in our children. Yet by paying tribute to our young Americans let us not lightly dismiss our responsibility to them. It is a duty — and it should be a privilege — for each of us "to lead in all gentleness, candor, and confidence, the youth of today into the straight and surer way of life, unselfishly and for the good of others. This way is entered by the door of respect and consideration. It is made easy by discipline, self-denial, and courtesy. It is the way the world's greatest and best men and women have traveled, and it is one royal way to contentment and happiness." To those of us who are responsible for the training of youth — and we all are in greater or less degree — this is a real challenge. A really great teacher understands human nature. We have only to review the life and teachings of that greatest of all teachers to know that this is true.

The biographical sketch of Hardy Cross, the 1944 recipient of the Lamme Medal for achievement in engineering education calls attention to the philosophy of his life as a man who regards teaching as a fine art, for which scholarship, productivity, and research are essential but in which good teachers are marked by the vision and inspiration of the men they train. How fine it would be if we could all give a little of ourselves to our youth. Yes, we urge them to "hitch their wagon to a star" and to follow the Golden Rule. But too often we forget to remind them that that star should not be regarded as something unattainable but as something enduring, something everlasting, something on which they can build their faith, their hopes, and their lives. In telling them "This is your America" have we provided, as their heritage, the right kind of star?

Some New Sweet Potato Machines and Equipment

By O. A. Brown and W. S. Anderson
MEMBER A.S.A.E.

SWEET POTATOES are an important food crop on many farms in the Southeast, most of them grown in small patches for local consumption. The cultivating, harvesting and storing practices have been developments based on the equipment on small farms. The stick method of planting, building beds with one-horse plows, using the same plows to turn out the sweet potatoes, and storing them in banks are all examples of practices developed by small growers without special equipment. The great number of machines as well as the random nature of their development are brought out in Mississippi Agricultural Experiment Station Bulletin 392, entitled "Sweet Potato Production, Mechanical Equipment Studies," by J. W. Randolph and W. S. Anderson. The bulletin also points out some of the problems encountered when the growing of a root crop of this kind is changing from manual to mechanical production.

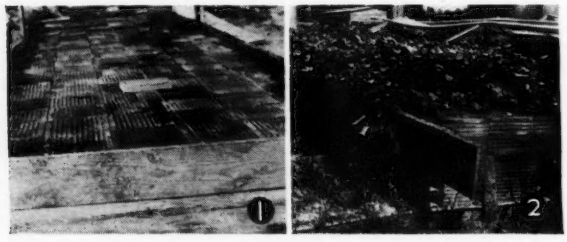


Fig. 1 A tile hotbed for sweet potato plants under construction. Fig. 2 The same hotbed covered with the plants grown

In the past few years agricultural engineers have been considering certain problems in the larger-scale and more economical production of this crop; obtaining and setting plants before it is too late to produce a profitable crop; preventing strong weed competition in a slowly maturing vine crop; and digging the potatoes from fields covered with heavy vines. Problems of producing and caring for and marketing the crop and of storing sufficient seed potatoes free from disease to produce another crop are grievous ones to farmers who are trying to increase production. The answer to all the problems in sweet potato production may be found in large part in more complete mechanization and a greater use of the more convenient sources of heat for producing plants and curing potatoes.

Some of the farm implement companies are showing interest in developing equipment that will better suit the needs of farmers who wish to grow sweet potatoes on a larger scale. Other developments are under way at experiment stations and on farms. This paper has been prepared to call attention to machines and equipment of recent development.

An Improved Hotbed for Growing Plants. A tile hotbed heated with natural gas, but which may be heated from almost any available energy source, was used in 1944 for the first time in our experimental work.

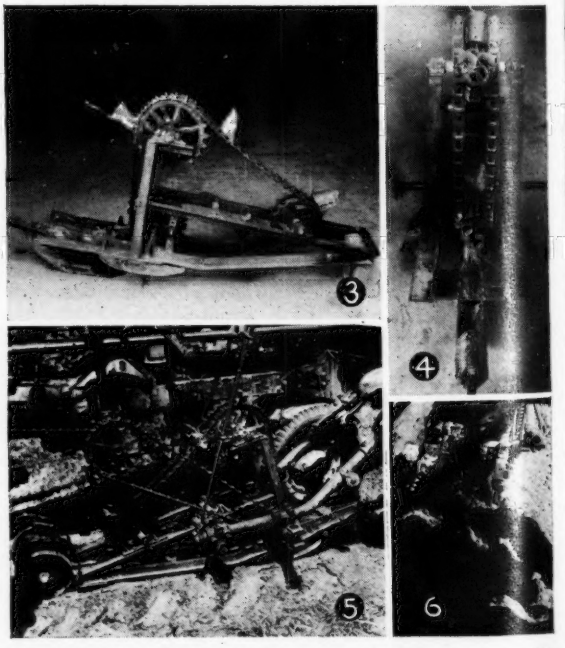
The bed was constructed mainly of 12x12x4-in hollow building tile and sawdust. The side supports of the bed were 2-in pine planks. A combustion chamber was built on one end of the bed and a gas stack on the other. The bed was 30 ft long by 7 ft wide. The retaining walls, 22 in high, were built on the ground sloping slightly upward from the combustion chamber end to the stack end. Sawdust was thrown on the ground within the walls and packed moderately, 10 in deep. At the firebox end and directly against the firebox, soil instead of sawdust was used in a layer 12 in wide and 10 in deep to prevent the sawdust catching fire. No sweet potatoes were bedded in this soil or on the bed over it. The tiles were placed on the sawdust to make a flat surface with the holes in the tiles end to end to make continuous openings the entire length of the bed to conduct the heated gas. Fig. 1 shows the bed under construction. The space, about 4 in wide, between the tiles and retaining wall on either side was filled with sawdust.

Soil was placed on the tiles and smoothed off so that there were approximately 6 in of soil on the end adjacent to the combustion chamber and 2 in on the gas stack or cooler end. The sweet potatoes were bedded on the soil and covered approximately 3 in with sawdust. Fig. 2 shows the bed covered with plants thus grown.

This bed proved generally satisfactory in fuel consumption and in plants produced. However, the temperature gradient from one end of the bed to the other was too great as the temperature at the stack end was too low for good plant growth. This probably means that the holes in the tiles were too small or that the depth of soil covering the tiles at this end was not correct.

A Sweet Potato Transplanter. Sweet potato plants have been and are being transplanted with commercial machines. The principal disadvantages of these machines are (1) speed at which they must travel while transplanting, (2) lengths of the machines, (3) weight of machines when loaded with water and operators, and (4) skill required of the operators to obtain uniform transplanting. The transplanters are sulky type machines and must be pulled behind a tractor in order to obtain the slow, steady speed required for transplanting. Some of the two-row commercial transplanters are more than 10 ft long. Add another 10 ft for the tractor, and the transplanter becomes quite out of place in terraced fields. The weight of four people (used on some two-row transplanters) is objectionable, but is not prohibitive; neither is it impossible to obtain operators. There is, however, need for improvement in transplanting equipment.

It would be advantageous if the transplanters were mounted directly on the tractor. Figs. 3 and 4 show a transplanting unit built to be mounted on the cultivator frame of the H (Farmall) tractor. Fig. 5 shows it mounted and in the planting position. The planter is reversible; that is, the same unit may be mounted



Figs. 3 and 4 A transplanting unit built to be mounted on a tractor cultivating frame • Fig. 5 The transplanting unit mounted and in planting position • Fig. 6 A rear view of the transplanter in operation

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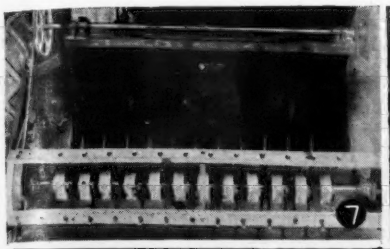
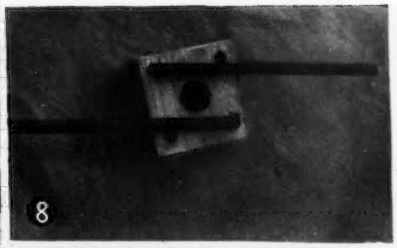

Fig. 7 This shows the inside mechanism of the drum used for picking sweet potato vines off the ground • Fig. 8 One of the bearings used on the drum shown in Fig. 7 • Fig. 9 Automobile rear axle used to drive the drum • Figs. 11 and 12 The drum shown in operation

on either side of the tractor.

The planter chains (shown in a side view in Fig. 3 and in a front view in Fig. 4) have cups spaced along the chains equal to the plant spacing. These planter chains are driven at ground speed so that as the planter moves forward the cups remain stationary with respect to the ground. The root of the plant projects beyond the cup. The plant is shown in the cup that has just crossed over the sprocket wheel in Fig. 3. As the cups move under the lowest sprocket wheel, the root of the plant drags on the bottom of the furrow opening between the sides of the furrow opener. The "ground slide" on either side of the planter pushes the soil into the furrow, thus covering the root of the plant. Since the cups do not move with respect to the ground, the plant is held in its position until the packing wheels come along and pack the soil around it. The rear sprocket wheel is mounted above the lower front sprocket wheel which causes the cup to lift out of the soil, leaving the plant in place. Fig. 6 shows a rear view of the planter in operation.

While this unit eliminates some of the objections to transplanters it has some of its own. It permits only one operator and imposes upon him the task of getting the plants at the right place at the right time. Because of this, the planter must be run at low speed and the operator is kept constantly on the alert. To compensate for this, the planter gives a uniform spacing, and if a plant is missed there is a double space. Another important feature is that the plants are released only when they are well packed and the water is deposited at the root of the plant.

The unit is experimental and changes to improve it are already under way.

A Sweet Potato Vine Harvester. There are three reasons that might be given for harvesting sweet potato vines: (1) Digging operations are made easier if the vines are removed from the row; (2) the vines have some feed value and if properly handled would probably pay for the harvesting operation, and (3) in areas of sweet potato weevil infestation the vines and roots left on the soil furnish food and shelter for the weevils. In order to meet the required specifications, a vine harvester should not only pick up that part of the sweet potato plant which is high in feed value but should do a good job of removing all the vines from the soil. With these specifications in mind we have been working with a harvester that has two parts, namely, a set of sweeps for cutting the vines loose from the beds and a rotating drum with disappearing fingers for freeing the vines from the soil and picking them off the ground.

Two half and one full sweeps were mounted on an HM middlebuster frame. The full sweep was mounted on a frame constructed so that the sweep and a depth wheel with a coulter were in front of the fore wheels of the tractor. The half sweeps were mounted on the shanks of the middlebusters. Coulters about three inches greater in diameter than the depth wheels of the middlebuster were fastened against the sides of the depth wheels for splitting the middles. The sweeps cut the anchor roots of the vines and also cut the vines loose from the hills. The part of the mechanism which performs the cutting operation is shown in Fig. 10. The coulters split the middles of the rows. The rotating drum which is carried behind the tractor completed the operation of getting the vines loose from the soil.

The drum we have been using for harvesting sweet potato vines is 14 in in diameter and has a crank with an offset of 2½ in. Fig. 7 shows the inside mechanism of the drum. As the drum rotates it protrudes and retracts the fingers (½ in steel) which extend a maximum of 5 in from the surface of the drum and then drop back flush with its surface.

Since the drum rotates about a crank, each finger must be supported on a bearing. In this drum, each bearing is made to support four fingers. The bearings are made of wood blocks 2x4x4 in. Two ¼-in bolts are put through each block to prevent splitting. Four ½-in holes are drilled on a 1¾-in radius from the center of the block equally spaced. The fingers are bent 90 deg at 2 in from one end and the short end put through the holes in the blocks. Fig. 8 shows one of the bearings with two fingers in place. In making the machine, two fingers are put into the other holes from the other side of the block. Between the bearings on the shaft are pieces of hard Masonite 4x4 in to prevent the fingers from slipping out of the holes. Each bearing is held in its respective position by a piece of strap iron running the length of the bearings on the crank and fastened to each with a wood screw. The drive shown on this drum proved to be inadequate and was replaced with the rear axle of a car (Fig. 9), which is driven from the power take-off and has proved quite satisfactory.

The drum is shown in operation in Fig. 11. Fig. 12 shows the drum in the same position as Fig. 11 after the loose vines have been removed from in front of it with a fork. Disposal of the vines after they are loosened from the soil will depend upon how cheaply they can be handled and what the demand is for such feed.

The mechanization of sweet potato farms has not reached, and probably never will reach, the place where an average farmer who grows sweet potatoes will have machines for handling only this one crop. The other row crops are cotton, corn, tobacco, peanuts, and vegetables. The machines a farmer uses should, in so far as possible, suit the conditions of all the crops he grows. There is also another condition imposed on machines to be used on southern farms by the short and winding rows resulting from the presence of contour terraces or uneven land. The limited use which machines have in sweet potato culture may be a reason why so few machines have been used to grow small acreages of this crop. As the acreage increases farmers are demanding better machines.

Experience has taught that machines to be used on the average

sweet potato field can be too long, that under most conditions a one-row machine is better than a two-row machine, and that there is a great need for training labor for specific operations with machines. A man who can drive a tractor is not necessarily qualified to prepare a sweet potato row for mechanical cultivation. Machines can not be used to set plants properly on poorly built rows. If the plants are irregular on the rows the cultivator will not do a good job of weed removal. If weeds are permitted to grow among the sweet potato plants, digging operations with machines are handicapped. The specifications, therefore, are important features.

A Farm Lighting Survey

By Lawrence C. Porter
FELLOW A.S.A.E.

VARIOUS farm lighting surveys made before the war showed that the average farm used 30 lamp bulbs. These surveys, however, were limited strictly to lamps used for general lighting purposes only. No account whatsoever was taken of supplemental lamps, such as radio panel lamps, refrigerator lamps, electric range lights, sewing machine lamps, electric handlanterns, flashlights, night lights, sunlamps, infrared lamps, egg candlers, lamps in baby pig and chick brooders, vacuum cleaner lamps, lighted electric clocks, etc., etc. Many such uses of light are of value and assistance in the operation of the modern farm. Furthermore, general lighting has progressed rapidly since the last farm lighting survey was made — before fluorescent lighting was developed.

In order to determine what the present situation is, and to show where lighting could be expanded to best advantage, the "Country Gentleman" recently cooperated with the lamp department of the General Electric Company in making a national survey of farm lighting. This survey was made and the data analyzed by National Analysts, Inc., for the research department of the Curtis Publishing Company. The survey was made by having members of Country Gentlewoman League Clubs take an inventory of the total number of electric light bulbs in use and on hand on their farmsteads. Enough questionnaires were distributed in January and February, 1945, to provide 500 returns. At the time of this report 479 interviews from 41 representative counties all over the United States had been received. A condensed summary of the results is contained in Table 1.

It is interesting to note that instead of 30 lamps per farm there are now 56.9 in use. It was found that 15.9 per cent of the 479 farms surveyed are already using one or more fluorescent lamps, 61.1 per cent of which are in kitchen and pantry, 19.4 per cent in bathrooms, 18.1 per cent in dining rooms, 13.9 per cent in living rooms, 4.2 per cent in bedrooms, 4.2 per cent in unoccupied rooms, 1.4 per cent in shops. (The total exceeds 100 per cent because some houses use fluorescent lighting in more than one location.)

It is also interesting to note that there are almost as many bulbs used in or on equipment as are used for general lighting — 24.3 versus 29.1 per farm, respectively.

The data in Tables 2, 3, and 4 is indicative of the many uses to which light may be applied on a typical farm.

There are three large fields for lamps in the postwar rural field: (1) newly electrified farms, (2) inadequately lighted farms, and (3) lighting on new farm equipment. In addition to farms there is a large number of rural establishments, such as gasoline stations, country stores, churches, etc.

If we set as our potential postwar objective the lighting of all new buildings in accordance with recommended practice and bringing under-lighted buildings up to that standard, then add to that the supplemental lighting of equipment used in the rural field, it is easy to foresee a need for at least 250 million lamps for the rural field alone in the five years following the end of the war.

TABLE 1. FARMSTEAD LIGHT BULB INVENTORY SUMMARY
(Number of Light Bulbs)

Geographical divisions	Returned questionnaires	In farmhouse		In outbuildings		In or on equipment		In reserve		Total	
		No.	Per farm	No.	Per farm	No.	Per farm	No.	Per farm	No.	Per farm
New England and Middle Atlantic	36	1354	37.6	535	14.3	1149	32.0	220	6.2	3259	90.1
East North Central West North Central	220	5184	23.5	2371	10.7	5655	25.8	795	3.6	14005	63.6
Mountain and Pacific	78	1356	17.3	392	5.1	2271	29.2	271	3.5	4290	55.1
South Atlantic East South Central West South Central	120	1600	13.3	295	2.5	1931	16.0	260	2.2	4086	34.0
Unclassified*	25	575	23.0	323	12.9	608	24.3	99	4.0	1605	64.2
Total United States	479	10069	20.9	3916	8.2	11614	24.3	1645	3.5	27244	56.9

*Received too late for original tabulation.

TABLE 2. PROBABLE SUPPLEMENTAL LIGHTING

Use	Number of lamps	Watts
Radio panel	2	1.8
Electric range	7	7
	1	25
Refrigerator	1	15
Electric clock	2	1.8
Vacuum cleaner	1	15
Cellar switch plate	1	6
Night light	2	7
Sewing machine	1	15
Flashlight	2	1.9
Bicycle head and tail lights	2	1.8
Egg candler	1	25
Toy train	12	1.9
Christmas tree	24	4
Baby pig brooder	1	100
Electric hotbed	8	50
Yard light	1	200
Baby chick brooder	4	250
Reflector spotlight*	1	150
Total	74	Average 44

TABLE 3. ADDITIONAL LIKELY SUPPLEMENTAL LAMPS

Use	Number of lamps	Watts
Disinfection (germicidal)	5	30
Sunlamp (RS)	1	275
Infrared (heat) lamp	1	250
Movie projector	1	500
Drying	4	250
Photoflood	2	
Photoflash	6	
Electric handlantern	1	3
Floodlamps	2	300
Total	22	Average 230

TABLE 4. ADDITIONAL LIGHTING POSSIBILITIES

Use	Number of lamps	Watts
Lighted ornaments	4	10
Black light (360BL)	1	15
Plantlight	1	150
Lighted house number	2	2
Switchplate indicators	13	0.5
Outdoor Christmas tree	4	150
Heating appliance indicators, (percolators, electric blanket, waffle irons, flat irons, toasters, etc.)	6	0.5
Home dehydrator	10	100
Lighted doorbell pushbutton	1	2
Clothes dryer (germicidal)	1	15
Sterile storage cabinet (germicidal)	1	15
Garden lighting	10	10
	4	100
Battery-operated closet lights	5	2
Ping-pong table lighting	2	150
Highpower spotlight	1	500
Automobile lighting	10	25
Tractor floodlights	2	50
Lighted-fuse indicators	6	0.5
Electric-circuit tester	1	0.5
Electric-fence indicator	1	0.5
Total	86	Average 38

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

LAWRENCE C. PORTER is illuminating engineer, Nela Park Engineering Division, General Electric Co., and chairman, A.S.A.E. Committee on Electric Light in Farm Production.

What Is There to Know about Farm Ponds?

By D. B. Krimgold
MEMBER A.S.A.E.

THERE is no need to repeat here what is now common knowledge among farmers, agricultural engineers, and others as to the importance and many uses of farm ponds. The purpose of this paper is to outline briefly what should be done to put the planning, design, and management of farm ponds on a sound basis.

The primary consideration in the design of a farm pond is the dependability of the water supply. Next in line is the proper and full utilization of that water supply. The hydrologic and structural factors entering into the dependability of the water supply are, in part, (1) the evaporation from water surfaces, (2) precipitation falling on the reservoir, (3) surface and subsurface runoff, (4) use (required quantities of water), (5) seepage, (6) silting, (7) stability of dams (usually earth fills), and (8) capacity and stability of spillways which in turn determine the stability of the dam.

First, let me say that average or mean values of hydrologic factors are of little or no value in connection with the determination of a dependable water supply.

The mean runoff, mean rainfall, or mean evaporation for a 10-year or even 20-year period may include exceedingly high values for 2 or 3 years, few if any values equal to the mean, and a large number of values far below the mean. What we are concerned with are not averages but values which may be expected 75, 80, 90, 96, etc., per cent of the time (equaled or exceeded in case of rainfall and runoff and equaled but not exceeded in the case of evaporation. Such values, when properly related to the amount of water to be drawn for use and to the dimensions of the reservoir, afford a means of estimating how frequently (or how rarely) the particular development may fail to supply the required amount of water. This in the last analysis is what one must know in planning a dependable supply. A complete discussion of this subject was given elsewhere[1] and will not be repeated here. It will suffice to say that to evaluate these factors properly one must have records for a period of about 20 to 30 years. Now let us see how many of these records are available.

Evaporation and Precipitation. For critical periods of little or no runoff and for expectancies to be considered in the design of small reservoirs and farm ponds, evaporation exceeds precipitation in practically all parts of the United States. We are therefore in most cases concerned with expectancies of evaporation minus precipitation. Adequate records of monthly and daily totals of precipitation for 30 years or longer are generally available. Records of evaporation, however, are very meager. Those from B.P.I. evaporation pans in the West are practically all limited to the summer months. There are practically no long-term records east of the Mississippi. Mean monthly and annual values of evaporation from shallow lakes and reservoirs computed by Adolph Meyer's formula and of rainfall for a 50-year period were recently made available in a publication, entitled "Evaporation from Lakes and Reservoirs", published by the Minnesota Resources Commission. The information used in the preparation of this publication must be worked up to obtain values of evaporation minus precipitation of various expectancies. This must be done on a seasonal rather than annual basis. The seasons of May through October and November through April will be found suitable in many locations. At the same time the validity of Meyer's formula must be verified by proper experimental installations in the several climatic regions.

Runoff. Runoff from small areas is determined mainly by precipitation, temperature, vegetation, soil characteristics, and physiography. All five vary greatly from one area to another. The first three vary also seasonally. There are practically no long-term records of runoff from small drainage areas. However, runoff records from watershed and plot studies of the Soil Conservation Service afford a means of arriving at rainfall-runoff relationships for most of the important agricultural regions of the United States. These records must be analyzed, the relationships developed, and expectancies of runoff determined from the long-term rainfall records. A beginning has been made by developing such relationships for the Claypan Prairies[1]. Runoff studies should be established in areas not represented by experimental watersheds from which adequate records are available.

Seepage. The great majority of farm ponds are located in natural watercourses. The sites are often on permeable alluvial deposits or gravel covered with only a relatively thin layer of slowly permeable or tight soil. In case of small farm ponds, where funds are limited, the tendency is to use the pond site as a borrow pit for the earth fill. It is seldom practical to select the material for the fill and to compact it properly. These conditions eliminate many sites which may be highly desirable from every other standpoint or result in failures where seepage is not given proper consideration. Little or nothing is known on rates of seepage and no practical methods have been developed to control it effectively in farm ponds. Yet there are several possibilities which should be investigated and adapted to farm ponds and small earth fills. Experience in irrigation canals indicates that clay blankets or small amounts of Bentonite and of similar admixtures may prove practical means for controlling seepage. Controlled silting for a short period after completion of the pond may prove the most practical and economical means of controlling seepage. This method cannot, however, be recommended until the principles and methodology have been carefully worked out on experimental installations. Such practical methods may greatly reduce seepage but could hardly be expected to eliminate it entirely. It therefore is necessary also to determine rates of seepage which should be provided for in the hydrologic design of ponds. Before undertaking the experimental work, the available information directly or indirectly related to this subject should be brought together and properly analyzed.

Use of Water. The amount of water needed for various purposes is often much smaller than that lost by evaporation. One must, however, know whether 10, 15, or 20 gal of water should be provided per animal unit, in case of water development for livestock, or whether 2, 4, or 6 acre-inches should be available for emergency irrigation, or whether barnyard and domestic use should be computed on the basis of 20, 30, or 50 gal per day per person or per animal unit. Information on this subject is available from various sources. A good deal of it is, however, more of the nature of "notions" than factual data. The existing information must be analyzed and the necessary studies made to eliminate guessing.

Silting. It is well known that unless the area adjoining the pond or reservoir is properly protected by vegetation, a small reservoir or pond may fill up in one storm. There are, however, many instances where adequate vegetation can not be established or maintained especially in small, deeply entrenched water-courses. Studies must therefore be conducted with a view to developing adequate preventive measures and practical methods for passing heavy silt loads through ponds. Density currents may or may not be the answer.

Stability of Earth Fills. A great deal of work has been done and rather definite specifications and procedures have been developed for use in the construction of earth fills for relatively large heads of water. This information is not now being used and probably should not be applied to small earth fills, the total cost of which does not justify any of the field tests involved. The tendency has been to play safe and to require far greater factors of safety than are necessary, thereby greatly increasing the cost of small reservoirs and ponds. Field studies of the paths of percolation through earth fills placed in accordance with common practice may show that 3 to 1 side slopes for heads of water less than 10 ft are excessive. Mechanical protection of earth fills such as riprapping is seldom practical on small reservoirs and farm ponds. Vegetation properly established and maintained is both effective and practical. The movement of water through small earth fills

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[1]Hydrologic Designing of Farm Ponds and Rates of Runoff for the Design of Conservation Structures in the Claypan Prairies, by D. B. Krimgold and N. E. Minshall, Soil Conservation Service Technical Publication 56, processed.

should be studied with a view to developing safe and practical methods of maintaining optimum moisture conditions in the fill both for structural stability and for maintaining adequate vegetation. Suitable grasses and shrubs must be selected for the upstream and downstream faces of earth fills.

Spillways. The most suitable spillway for a small reservoir or farm pond is a properly protected grassed waterway. Outdoor laboratory studies conducted in recent years by the Soil Conservation Service show definitely that bluegrass, bermuda, and other vegetal linings can carry large quantities of water with high velocities. There are, however, important areas where adequate vegetation can not be maintained at the time when it is most needed. In still other areas vegetation which will safely carry high flows is destroyed or made ineffective by sustained small flows. The method now used to meet these conditions is to provide pipes or drop-inlet culverts in addition to a vegetative channel intended to function as an emergency spillway. This requires additional heights of fill which, while greatly increasing the yardage, and therefore the cost, does not provide any additional storage. There is room for further study of this phase especially in connection with fish ponds in which cleanout pipes must be provided. Float valves or other inexpensive practical means must be developed whereby the relatively small sustained flows can be disposed of without unduly increasing the height of the dam. The experience with culverts through highway and railroad fills should be critically examined, and simplified, inexpensive outlet structures should be tested under field conditions.

Utilization of the Water Supply. The many uses of farm ponds involve a number of appurtenances and auxiliary installations. Their design and selection may in large measure determine the extent to which the water, made available through the construction of a pond or reservoir, will be utilized. Where cheap electric power is available, motor-driven pumps with suitable characteristics can make the pond a source of water not only for livestock or fish production but also for spraying, fire fighting, overhead irrigation, and of running water in the barnyard and even in the home. Where electric power is not available, or is too expensive, hydraulic rams and other sources of power should be considered. Windmills are used extensively on wells in the Great Plains and elsewhere. The several available means of pumping water should be examined with a view to introducing such changes as may be needed to make them most suitable for use in connection with farm ponds. Pumps are not needed where adequate flow and pressure can be obtained by gravity. Small filters, chlorinators, and water-purification units would make water from ponds available for culinary use, and even for drinking.

Improved designs of watering troughs must be developed to keep livestock water at the proper temperature throughout the year. An ample supply of water at the right temperature goes a long way toward increasing meat and milk production on the farm. The agricultural engineering department of the University of Missouri is trying out an experimental installation on the farm of the president of the University near Columbia, Missouri. Such work should be encouraged and extended to other locations.

The foregoing discussion does not by any means cover all phases of the planning, construction, and management of farm ponds. Pond management for fish, wildlife, and recreation not mentioned in this paper is a large subject on which much has been written and which has been recently given considerably more attention than the other phases discussed in this paper.

The question of aquatic and of shoreline vegetation and the problem of mosquito control are other factors which were not discussed but must be considered in connection with farm ponds and reservoirs.

Much has been said recently about the possible effect of farm ponds on floods. It is not unreasonable to assume that, with a sufficient number of ponds properly designed for that particular purpose, the frequency and extent of inundations of valuable bottom land may be appreciably affected. The effectiveness of farm ponds in controlling floods on the Merrimack River is being investigated by the agricultural experiment station and other state agencies of Missouri in cooperation with the Soil Conservation Service. The results of this work should be examined and the studies extended to other areas.

Farm ponds and small reservoirs may be, in some special cases, utilized in replenishing ground-water supplies and raising the water table. This phase involves geologic and physiographic consideration which must be carefully evaluated and substantiated by field trials.

The Committee on Farm Ponds and Reservoirs of the A.S.A.E. might well take the initiative in bringing together the engineers, hydrologists, biologists, and others who are concerned with the various phases of planning, construction, and management of small reservoirs and farm ponds. Definite steps should be taken to establish a joint committee of the A.S.A.E. and of other scientific and professional groups concerned with the various phases of this large and important subject.

Drainage and Irrigation Recommendations

The proposed A.S.A.E.-sponsored recommendations on drainage and irrigation, drafted by a group of members of the American Society of Agricultural Engineers representing the Society's Soil and Water Division and published in AGRICULTURAL ENGINEERING for March, 1945, have now been revised on the basis of comments and suggestions received from several agricultural engineers in the field of soil and water conservation, and are submitted herewith for any further suggestions for changes or additions prior to submitting them to the Council of the Society for approval. To facilitate handling, members of the Society who may wish to contribute additional suggestions or comments should mail them promptly to Secretary, A.S.A.E., St. Joseph, Michigan.—EDITOR.

1 That the A.S.A.E. request the Secretaries of the U. S. Departments of Agriculture, War, Commerce, and the Interior to issue statements defining the nature, scope, authority, responsibility and objectives of their respective departments in connection with water problems, including irrigation, drainage, flood control, and associated activities.

2 That the A.S.A.E. believes there is a need for each state to coordinate its activities in connection with water problems and the development of irrigation and drainage projects, and that special effort should be made by the legislature and the governor in each state to avoid unnecessary duplication or conflict of activities by different departments or groups concerned with water problems.

3 That the A.S.A.E. go on record as favoring the development of drainage and irrigation works as a long-time program based on national needs for food production and land-use adjustment rather than as postwar projects to use surplus labor and equipment or to develop lands for settlement. The A.S.A.E. should recommend that all proposed drainage and irrigation projects, whether they are to be financed by public or private funds, should be investigated to determine the suitability of the soils for such use, the economic feasibility of the projects, and the adequacy and quality of the water supply for irrigation projects.

4 That the A.S.A.E. should recommend that feasible drainage and irrigation projects be approved and developed in the order of their importance as food production areas, considering the benefits which can be expected in relation to cost of the work. The following order of priority should apply to drainage and irrigation work:

(a) Projects in good condition so far as the main works are concerned but where additional farm facilities, or improvement of existing drainage or irrigation facilities or of irrigation water supplies, are needed to increase production.

(b) Projects now in good condition where provision for adequate maintenance and increased efficiencies is needed.

(c) Projects needing extensive rehabilitation.

(d) New projects where the land is suitable for drainage or irrigation, available irrigation water supplies are adequate and of good quality, and which have been found by investigation to be economically feasible.

5 That the A.S.A.E. recommend to the Department of Agriculture, and to land-grant colleges in states where drainage is a major problem, that an extensive program of drainage research be undertaken comparable to the irrigation research program in the western states.

6 That the A.S.A.E. Committee on Curriculums give additional consideration to the need for including as many as possible of the fundamental engineering courses as required subjects or electives in the agricultural engineering curriculum. Some of the courses which are especially valuable for engineers who expect to do soil and water conservation work are Advanced Surveying (not highway or railroad), Advanced Hydraulics (including open-channel flow and water measurement), Fluid Mechanics, Hydrology, Soil Mechanics, Soil Physics and Chemistry, Geology, and Reinforced Concrete Design.

Developments in Terrace Spacing

By C. E. Ramser
FELLOW A.S.A.E.

AT THE beginning of the twentieth century terracing was not widely practiced outside of the southeastern part of the United States. In this section of high rainfall intensities, shallow topsoils, rolling topography, and one-crop farms, erosion had taken an enormous toll of the original highly productive soils, and terracing had apparently been quite generally adopted by the farmer only after great reductions in crop yields pointed unmistakably to the cause. In seeking a remedy it was likely found that in order to continue one-crop farming — sometimes alluded to as mining the soil with continuous cotton — some sort of artificial practices must be employed, and as a result terracing was quite generally adopted.

However, much of the original terracing work hardly deserved the name, since it often consisted largely of hillside ditches spaced so far apart that, while they eliminated unsightly gullies, there was some question as to whether the surface erosion losses or sheet washing was appreciably reduced. In order that the accumulation of runoff water, coming from the large drainage area between the terraces, could be safely removed from the field without overtopping the terrace embankments, it was often found necessary to give the terrace channels so much fall that excessive erosion occurred in the terrace channels. Another reason for using this large fall was to remove the eroded soil that tended to accumulate in the ditches and thus prevent their filling and overflowing. The landowner in most instances evidently felt that with the elimination of the gullies up and down the slopes he had successfully solved his erosion problem. The excessive fall in these ditches often eroded deep channels, and instead of having gullies up and down the slope gullies developed across the slope that often could not be conveniently crossed with farming machinery.

The more thoughtful farmers began to realize that, in order to be effective in diminishing soil losses, both the spacing of the hillside ditches or terraces and the fall of the channel must be greatly reduced. Some of the more ardent soil conservationists among them went so far as to lay out the ditches or terraces without any fall so as to reduce the speed of the water and thereby the soil movement along the terrace channel to a minimum. Also on some of the steeper slopes, terraces were placed so close together that there was only room enough for three or four rows of cotton between them. These were commonly referred to as bench terraces which developed by plowing the soil downhill year after year.

This was the state of affairs in the terracing world when I began a terrace-investigation trip for the Drainage Division of the USDA Office of Experiment Stations in the fall of 1915. At that time I had no preconceived ideas on proper terracing practices since I had never seen a terrace before receiving this assignment. Knowing, however, the purpose for which terraces are constructed I was not long in coming to the decision that about 90 per cent of the fields visited were inadequately protected against the ravages of erosion, and if it had not been for the few soil-conservation-minded farmers that were found in each state visited, I would no doubt have become as much disinterested in the practice of terracing as were many of the farmers who related their own disastrous experiences, apparently unwilling to admit that better results might have been attained with better terracing methods.

After visiting some of the most satisfactory terracing work, it was obvious that there was no use wasting time on investigations of many of the poorly terraced fields except to determine the causes of failures. Most of my time was therefore devoted to surveys and observations of the best terracing work. There was so little at that time that I believe I am safe in saying I visited practically all the good terracing work of that period while on this trip, most of which was called to my attention by the Extension Service personnel and others of the various state agricultural colleges.

After nearly thirty years of experience in terracing, I have developed a warm place in my heart for these early conservation-minded farmers who did so much to show the people of the South that terracing should not be condemned on the basis of past experiences and that it would work satisfactorily if given only half a chance. I do not know how many of these early pioneers in terracing are still carrying on since many were past middle age when I passed through. They certainly deserve a great deal of credit for the part they played in creating an erosion consciousness in the minds of their neighbors and in fostering better terracing practices in their immediate community.

The states of North Carolina, South Carolina, Georgia, Alabama, and Mississippi were visited on the trip made during 1915 prior to the preparation of Department Bulletin 512, entitled "Prevention of the Erosion of Farm Lands by Terracing," and on a later trip prior to preparation of Farmers' Bulletin 997, "Terracing Farm Lands," the states of Tennessee, Louisiana, Texas, and Oklahoma were visited. This paper will be confined principally to the first trip.

A great diversity of opinion was found to exist among the better farmers as to the best form of terrace to use and the rules employed in planning a system of terraces. Perhaps the greatest difference was whether terraces should be laid out level or with a fall or grade along the terrace channel. It is believed that these differences in most instances could be attributed directly to different conditions of soil and topography, different farming methods, or a different attitude as to how much erosion constituted a serious threat to the future productivity of the land.

I do not believe a better picture could be given of conditions that existed at that time than by quoting excerpts from my notes based on interviews with the most conservation-minded farmers in each state that I visited on my first field trip during 1915. The following is from an interview with W. H. Conway, of Chilton County, Alabama:

"Mr. Conway is a farmer and the county agricultural demonstration agent and is a firm believer in the level terrace. His first method of terracing was to give fall to the terrace bank so that the accumulated water would flow off at the ends through a drainage outlet. Most of his farm was terraced in this manner. These terraces were continually breaking and washing gullies in the fields at the breaks and at the ends of the terraces. He stated that they were entirely unsatisfactory and really did more harm than good, because without terraces the water ran off the land mostly in sheet form while with terraces it would accumulate behind them until a break occurred and then rush through the break at a high velocity, washing deep gullies and breaking all of the terraces below. In the light of later knowledge the graded terraces no doubt were improperly laid out and poorly maintained. Mr. Conway plowed up these terraces and constructed level terraces on about 100 acres of his 150-acre farm. These level terraces have given perfect satisfaction where they have been constructed properly. The theory of the level terrace is that it holds the water practically where it falls, allows most all particles of soil suspended in the water to settle and not be carried away, and thus minimizes the erosive action of the water. The water stored behind the terrace either is absorbed by the soil and subsoil or passes off slowly around the ends of the terrace. Mr. Conway advocates that the distance between level terraces in elevation should be 2½ to 3 ft; that the terraces should be about 1½ to 2 ft high and about 10 to 12 ft wide at the base. A terrace of these dimensions would afford ample storage capacity behind the terrace to provide for the heaviest rain. Water stored in this manner finds its way slowly into the ground and insures a plentiful supply of moisture in times of drought; thus a portion of the water is not only prevented from running off, eroding the surface of the ground and carrying away the most fertile part of the soil, but is retained in the soil to augment the usually deficient supply of ground water in hillside land.

"Mr. Conway reported that no damage had ever been done to his crops by the accumulation of water above the terrace. During the growing season this water seldom remained on the surface longer than a day, but during the wet season — before the seeding of crops — the water would sometimes remain a week, depending upon the saturated condition of the soil. The upper 8 to 12 in of

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the soil is a gray sandy loam, rather loose, and capable of absorbing considerable water; the subsoil in this section is generally a tight red clay, more or less impervious to the flow of ground water. No badly eroded spots were found on Mr. Conway's farm. Only a few breaks were found in the terraces, and these occurred generally along the line of old gullies which had been washed out previous to the terracing of the land. At these places the terraces were not built up sufficiently high and were overtopped by the surface water. Several terraces were constructed ½ mile in length — continuous embankments with outlets at the ends."

The following is quoted from my notes taken during a visit with C. T. Ames, director of the Holly Springs state agricultural experiment station, Mississippi:

"An inspection of terraced fields on and near the state agricultural experiment farm near Holly Springs, Mississippi, was made on September 14, 15, and 16, 1915. The land in this section of Mississippi is badly eroded. In fact, I do not know of any place where the soil washes so easily. The experiment farm was a typical example of eroded lands in this section prior to improvements commenced about 9 years ago. Three principal types of soils are to be found on this land — the original topsoil is a fairly loose brown sandy loam. Most of this type has been washed away. This soil is underlaid by a yellowish red and, in some instances, a white subsoil which possesses many of the qualities of hardpan. When dry it is extremely hard and impervious to water, but when wet it crumbles away and erodes quite easily. This soil does not drain readily.

"C. T. Ames, the director of this station, has achieved wonderful success in reclaiming the station lands. The results of his persistent, hard, unremitting labors are remarkable, not to say miraculous. He has transformed one of the worst types of eroded land, where most of the fertile particles of soil had been washed off, into a profitable farm. The importance of his work cannot be too fully emphasized. He has proved to be a fact what the majority of people declared to be impossible by the reclamation of this farm, and the lesson to be gained therefrom is a most valuable one to the whole country and particularly to the South where similar examples of eroded land exist.

"In the reclamation of this farm, Mr. Ames proceeded about as follows: Gullies were first plowed in and filled up and an attempt was made to grow Bermuda grass or lespedeza on this practically barren soil to prevent further washing of the soil. The worst gullies were prevented from washing further by planting locust trees and other shrubs on the banks and in the bottoms. The land was further prevented from washing by a system of terracing or hillside ditches. The terraces were generally given about 2 to 7 in fall per 100 ft depending upon the slope of the land, the greater fall being given on the steeper slopes, and were placed from 4 to 8 ft apart in elevation, the larger distance being used on the steeper slopes. Deep gullies were reclaimed in some cases by damming them up and allowing the space behind the dam to fill up. This is a slow process of reclaiming land but much the cheapest.

"An inspection of the results of the above work showed a wonderful improvement to have been made in the farm, and the work of the erosive agents — alternate freezing and thawing and moving water—had been greatly checked but not entirely stopped. However, the task is too stupendous a one to entirely eliminate erosion, and it is not believed the methods employed by Mr. Ames could be greatly improved at a reasonable cost. The erosion which still takes place is so small as compared with that before reclamation that it is considered by inhabitants of this section to be negligible.

"Mr. Ames does not attempt to cultivate the terraces or the land on the steeper slopes on his farm. This land is seeded down and kept for pasture. It would be next to impossible to retain a cultivated terrace with fall on the steeper slopes. Mr. Ames objects strenuously to placing his terraces closer together on the grounds of inconvenience in cultivation. However, if he desired to check erosion still further, this could be done by placing his terraces closer together and decreasing the fall of the terraces. Each terrace would then be required to provide for the removal of water from a smaller drainage area and could remove the smaller amount of water with less fall, resulting in considerably less erosion and consequently the retention of more of the fertile particles of the soil."

You no doubt have noted that Mr. Ames' views on terracing are radically different from those of Mr. Conway in Alabama, but he was dealing with badly eroded impervious soil while Mr. Conway was concerned with lands having soils of a more permeable nature.

The following statements are quoted from notes after visiting

TABLE 1. DATA OBTAINED FROM SURVEYS OF GRADED TERRACES

Owner of Farm	Location and Field No.	Height			Base Width			Vertical Dist. Bet. Terraces			Slope of Land Ft. per 100			Fall of Ter. Ft. per 100			Length of Terrace		
		Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
		Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.							Ft.	Ft.	Ft.
Braselton #1	#1 Braselton, Ga.	1.0	1.2	1.1	11.7	14.4	12.8	3.4	4.0	3.7	4.0	5.7	4.4	0	0.72	0.30	165	320	220
	#2	0.4	1.1	0.8	10.0	12.8	11.6	3.2	4.4	3.8	4.7	10.1	7.3	.71	1.19	.95	580	1,110	740
Ames	#1 Holly Springs, Miss.	0.9	1.4	1.1	7.5	8.5	7.8	8.2	8.5	8.3	4.0	20.0	10.0	.57	0.68	.63	220	1,150	700
	#2	.4	0.6	0.7	10.5	12	11.2	7.5	9.2	8.3	7.5	11.6	9.9	.56	.90	.70	510	700	625
Turner	Cullman, Ala.	.6	.9	.7	.7	8	7.8	2.5	4.2	3.2	5.6	11.2	8.7	.68	.82	.76	205	560	400
Williams	#1 Winder, Ga.	.4	1.0	.7	13	16	14.2	4.2	4.5	4.3	4.6	5.6	5.1	.75	1.17	.92	80	520	295
	#2	.4	1.7	1.05	7.6	10.5	9.0	2.1	4.1	2.9	3.4	5.3	7.3	0	1.63	.9	145	1,300	455
Chandler	Winder, Ga.	1.0	1.2	1.1	7.5	9.1	8.4	4.1	6.8	5.6	4.6	11.3	9.3	.36	.96	.81	280	900	565
D. Smith	#1 Winder, Ga.	0.6	1.8	0.9	11.0	14.5	12.5	2.9	4.8	3.9	3.9	19.2	9.7	0	1.06	.51			660
	#2	.5	1.6	1.1	12.8	19.0	15.5	3.8	7.8	5.7	4.4	16.1	11.2	0	0.48	.33	415	820	670
Bush	Winder, Ga.	.4	1.3	0.9	5.2	8.0	7.1	2.0	5.6	3.9	5.1	9.6	6.8	.65	2.80	1.25	250	460	345
Heptinstall	Littleton, N.C.	.6	0.9	.8	10.0	14.0	12.4	4.8	7.1	4.2	5.6	15	8.6	.51	0.51	0.51			900
Mangum	Wake Forest, N.C.	.3	.6	.3	25	50	33	6.6	8.9	7.7	9.9	18.2	14.0	1.69	2.06	1.88	710	1,260	1,200
Jenkins	" "	.4	1.0	.65	26	36	30	2.0	3.6	2.8	4.7	9.3	5.0	1.76	2.24	2.00		980	900

TABLE 2. DATA OBTAINED FROM SURVEYS OF BROAD LEVEL TERRACES

Owner of Farm	Location	Age of Terraces (yrs.)	Terraces: Height Min. (Ft.)	Height Max. (Ft.)	Height Av. (Ft.)	Base Width Min. (Ft.)	Base Width Max. (Ft.)	Base Width Av. (Ft.)	Vert. Distance Between Min. (Ft.)	Vert. Distance Between Max. (Ft.)	Vert. Distance Between Av. (Ft.)	Slope Distance Between Min. (Ft.)	Slope Distance Between Max. (Ft.)	Slope Distance Between Av. (Ft.)	Av. Extreme Variation in Level (Ft.)	Slope of Land in Ft. per 100 Ft.: Min.	Max.	Av.
Conway	Thorsby, Ala.	4	0.8	1.4	1.1	10.0	13.0	11.6	2.3	3.4	3.0	60	170	110	0.9	1.4	4.7	2.7
"	" "	3	1.2	1.6	1.4	8.0	9.0	8.2	0.8	3.7	2.7	24	110	95	.4	1.8	5.2	2.8
Mims	" "	2	.5	1.1	0.8	6.0	11.0	8.8	2.5	3.9	3.0	24	95	44	.5	3.9	12.6	6.8
Lowery	" "	2	.8	1.2	1.0	5.0	10.0	8.0	2.9	4.4	3.2	20	65	40	.4	5.0	18.8	8.0
Gore	" "	2	.8	1.3	1.2	9.0	12.0	9.5	2.2	4.1	2.7	15	50	36	.5	5.8	19.0	7.5
Fuller	Cullman, Ala.		.7	1.5	1.1	8.0	13.0	10.0	1.9	4.3	3.4	33	190	60	.9	1.6	20.0	5.7
State Exp. Farm	Athens, Ga.		.7	1.0	.8	6.5	7.0	6.8			4	43	60	58	2.6	5.5	9.8	6.9
Hardigree	Winder, Ga.		.6	1.1	.9	5.9	10.6	8.5	3.8	6.1	4.8	18	85	40	1.4	5.7	21.5	11.8

the farms of Dave Smith and Pink Williams near Winder, Georgia.

"Surveys of several fields were made on the Dave Smith farm, 4 miles south of Winder. His terraces have been laid out from 8 to 14 years and they are the best broad level terraces yet found throughout the South. Mr. Smith's farm is in excellent shape. He plows it deep and has retained through his system of level terracing practically all the rich fertile humus on the land which by proper tillage has been incorporated into the soil. He is bothered practically none from wet places in his field due to standing water. He cultivates the terraces, putting a row of cotton or corn on top and one on each side. The low furrow on the upper side of the terrace lies between two rows. The older terraces are from 15 to 20 ft broad at the base. There are practically no washes on Mr. Smith's farm.

"A call was made on Pink Williams who has been practicing the cultivation of terraces for 20 years. Mr. Williams is a strong advocate of the graded terrace. He advises the use of a fall 2½ in per 30 ft, or about 8 in per 100 ft. He says with more fall gullies are formed above the terraces and the cream of the soil is washed away. He insists that it is impossible to hold the water with a level terrace, but he uses about 5 ft difference in elevation between the terraces which no doubt accounts for the poor results with level terraces. He makes his terraces broad and high. He has one of the best terraced farms I have seen. There are no breaks in his terraces but he has given some of them more drop at the ends than his usual amount and bad washes have occurred above some of the terraces. He claims that with less fall these particular terraces would be unable to hold the water which accumulates at the ends. There seems to be very little washing in his field along the terraces except at and near the ends. The slope of the field investigated is probably no more than 7 or 8 per cent. The soil on his land is a gray sandy loam with a red clay subsoil. The topsoil washes quite readily. He does not turn the terrace up a great deal at depressions or gullies but builds the terrace up high at these places. He uses judgment in laying out the terraces and varies the slope accordingly. He uses a very large plow in throwing up the terraces, plowing a strip 10 to 12 ft wide, and then throws it up three times, once after each rain, in order to build it up to the desired height. I believe level terraces could be used to good advantage on Mr. Williams' place as the soil is sandy and contains a great deal of humus. The terraces on his farm are the best examples I have seen of graded terraces. The secret is that they are built broad and high and are carefully and properly laid out."

The following is taken from notes after visiting the farm of J. M. Dean, about three miles west of Spartanburg, South Carolina:

"On November 16, 1915, I called on J. M. Dean, about 3 miles west of Spartanburg, the most prominent and, said to be, the best farmer in the county. He is a firm believer in the broad, level, cultivated terrace and has some excellent examples of this style of terrace on his farm on more or less rolling land. He has no real steep land. He uses this type of terrace in cultivated fields and pastures and builds them up remarkably high and broad in a couple of years. He has very few breaks in his terraces and the only washes that occur are near the ends where some of the terraces have been turned down grade. He throws up his terraces with a No. 40 (16-in) Oliver plow, and in replowing a field he always uses this plow for the first four furrows on the terrace. The plow is pulled with four mules, two on each side of the terrace."

The following letter in reply to an inquiry was received from R. M. Gidney whose 320-acre farm I visited near Shelby, N. C., in Cleveland County; at that time Cleveland County was considered to be the best terraced county in the state and was generally styled the "county of terraces."

" . . . . I find level terraces here prove satisfactory. We don't plow across but run rows with terraces. We cultivate, drill and reap across our terraces. I find where fall is over 1½ in to the rod that land washes and terraces break more than level terraces with right spacing. System work is much better than guess work. I would say, first, if possible to control water, give me a level terrace, otherwise ½ to 1½-in fall to the rod with right system of spacing. One-half to 1-in fall holds the land and controls the water well. Our level terraces built broad do excellent work by holding water and all accumulation on the land. My 30 years' experience with level terraces convinces me that we can build land faster by keeping all we can on the land. The cultivated terrace is much better than the old way of building a ridge to grow up in weeds. I am using my influence to adopt cultivated terraces as much as possible in my county."

About 75 farmers and landowners were interviewed and 100 terraced fields were inspected on this trip. Approximately thirty of the best terraced fields were surveyed to determine the height, base width, spacing, and grade of terraces and slope of the land. Also careful observations were made of any erosion between terraces, nature of crop, and breaks in terrace embankments.

Proper methods of terracing were discussed at length with experienced farmers and county agents, men who were pioneers in the practice of terracing and were vitally interested in the preservation of their lands for themselves and their posterity. The deductions and conclusions reached were the result of an endeavor to treat from an engineering standpoint the information obtained from actual field observations of field conditions in connection with the data derived from field surveys and the advice and opinions of the best informed and most experienced farmers.

In Tables 1 and 2 are given data obtained from surveys of graded terraced and level terraced fields, respectively. In Fig. 1 data from these tables are plotted showing the spacing of terraces for different land slopes. In this figure the circles represent graded terraces and the crosses level terraces. Judging from the way these points are scattered, it can be seen that not much attention was paid to slope in spacing terraces. These points, however, seem to indicate that the spacing of graded terraces was somewhat increased with increase in land slope and the level-terrace spacing does not seem to have any apparent relation to slope.

From these data it is obvious that the proper spacing of terraces with regard to the land slope had not been given much thought. Field observations disclosed that where the terraces were

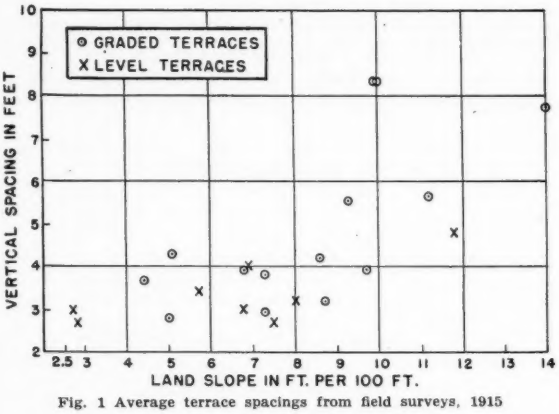

Fig. 1 Average terrace spacings from field surveys, 1915

spaced far apart considerable erosion resulted which was seen to be greater on the steeper slopes where the runoff water often overtopped the terraces. With this information it was decided that the channel above the terrace must be planned large enough to take care of the runoff water without its overtopping the terrace and that the spacing should be such as to prevent appreciable erosion on the land slope between the terraces. From the data obtained in the field surveys and the field observations of erosive conditions between the terraces, it was decided that vertical spacings of 3, 4, and 5 ft on land slopes of 5, 10, and 15 ft per 100 ft would give satisfactory results. After the spacing had been determined, it then became necessary to decide upon the most practical height of terrace from the standpoint of construction, maintenance, and operation of farm machinery. From survey data and field observations it was decided that the top of the terrace ridge should be 15 in higher than the lowest point in the channel. It then became necessary to determine what grade the channel should have to remove the runoff water at the rate that it would be delivered to the channel. This in turn required a knowledge of the intensity of rainfall for short periods.

In 1915 no analyses had been made of the probable frequency of rainfall intensities of different amounts and short durations as was subsequently made by Meyer and later by Yarnell. It therefore became necessary in order to obtain basic data for the proper design of graded-terrace channels to search the Weather Bureau records for existing rainfall-intensity data. Practically all of the data available at that time in the humid region of the United States were plotted covering intensities for 5, 10, 15, 20, 25, and 30-min periods and an envelope curve was drawn using rates of rainfall in inches per hour (y) as ordinates and duration of rainfall in minutes (x) as abscissas. This curve (Fig. 2) was later extended to include rainfall rates up to 60 min, the equation of the curve being $y=(30/x)+3$. This curve very closely approximates the Yarnell rainfall-intensity data for Georgia for rainfall durations of 10 to 45 min of 10-yr frequency. Since values of rainfall intensity for periods ranging from 11 to 47 min were used as times of concentration in designing graded terraces by means of the Rational Method ($Q=CIO$) in computing runoff, no appreciable changes would need be made today in the design of terraces in light of the more up-to-date rainfall records. According to this method the maximum discharge will take place when water from the most remote point on the drainage area above the terrace reaches the terrace outlet, provided the rate of rainfall continues uniform for a period equal to that required for the water to travel from the upper to the lower end of the drainage area. Hence, if the length and grade of the terrace be known and the average velocity of flow be computed, the time interval can be readily obtained. For instance, if the time interval is found to be 30 min, then the maximum rate of rainfall to be expected would, from the curve, be 4 in per hr. In computing this time interval, the distance from the upper to the lower end of the drainage area was taken as being equal to the length of the terrace, the distance between terraces being disregarded. Furthermore, the velocity at the lower end of the terrace was used in computing the time interval. These two practices would result in the use of a little larger rate of runoff, thus being on the side of safety.

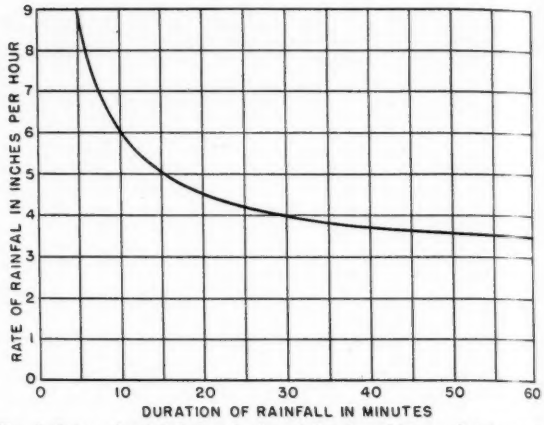

Fig. 2 Rates of rainfall for short periods, for which graded terraces were designed

Field examinations of a great many graded terraces disclosed that erosion of average soils in terrace channels takes place where the grade exceeds ½ ft per 100 ft. While not much noticeable erosion occurred at this grade, it was found from later experiments at the erosion-experiment stations that considerable fine material was carried off in the runoff water. It was finally decided to use the following values in the computations for the design of graded terraces: Base width of terrace, 10 ft; height of terrace, 1¼ ft; depth of flow, ¾ ft; and value of n in Kutter's formula 0.035. Experiments conducted later at the soil-erosion experiment stations indicated that using a value of 3.035 for n was practically correct. Using the velocity computed by the Chezy formula, $V=C\sqrt{rs}$ (where C is the constant determined from Kutter's formula, r the hydraulic radius, and s the slope), the time of concentration was determined for terraces of different lengths. The corresponding rates of rainfall were obtained for these times of concentration from the rainfall curve in Fig. 2, these being the rates of runoff that would obtain at the lower ends of the terraces assuming all of the rainfall to run off. Two factors of safety are included in the above computations: (1) the depth of flow was taken at only ¾ ft, whereas the terrace is 1¼ ft high, and (2) all of rainfall is assumed to run off, whereas a portion of it would enter the soil. Until better terracing work is done, experience indicated that a wide margin of safety is most desirable in terrace design owing to the possible piling up of the water due to obstructions, to the likelihood of diminished height due to carelessness in maintenance,

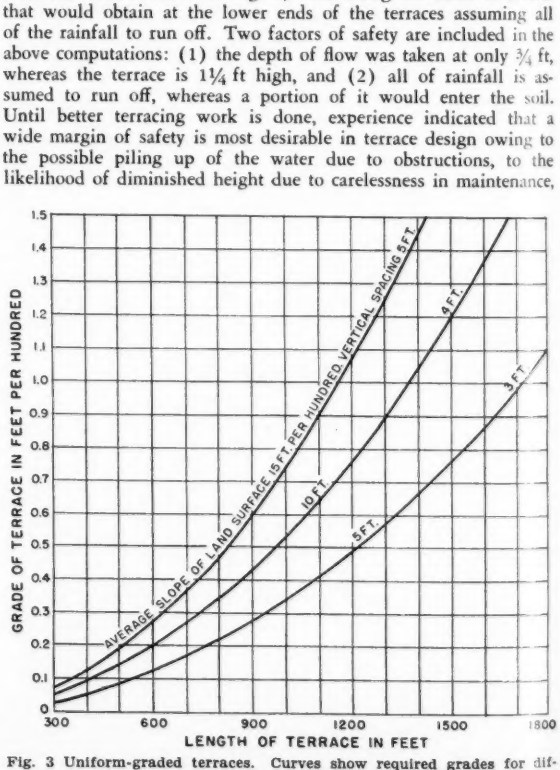
GRADE OF TERRACE IN FEET PER HUNDRED
AVERAGE SLOPE OF LAND SURFACE, IS FT. PER HUNDRED
VERTICAL SPACING 5 FT.
4 FT.
3 FT.
10 FT.
5 FT.
LENGTH OF TERRACE IN FEET

Fig. 3 Uniform-graded terraces. Curves show required grades for different land slopes, terrace lengths, and vertical spacings

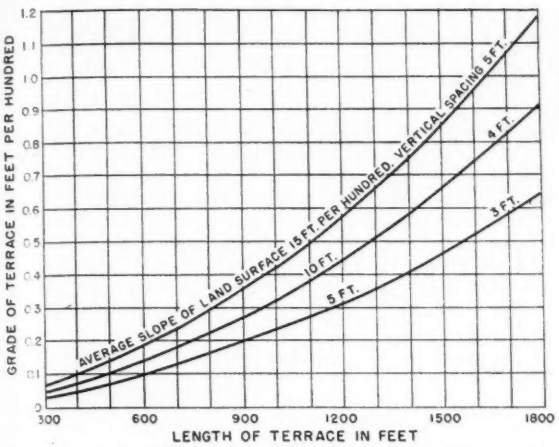
GRADE OF TERRACE IN FEET PER HUNDRED
LENGTH OF TERRACE IN FEET
AVERAGE SLOPE OF LAND SURFACE 15 FT. PER HUNDRED, VERTICAL SPACING 5 FT.
4 FT.
3 FT.
10 FT.
5 FT.

Fig. 4 Variable-graded terraces. Curves showing required grades for different land slopes, terrace lengths, and vertical spacings

to abrupt reduction in grade due to faulty surveying, and to inadequate allowance for settlement of the terrace embankment.

As stated in the foregoing discussion, it was found that vertical spacings of 3, 4, and 5 ft gave the most satisfactory results on slopes of 5, 10, and 15 ft per 100 ft, respectively. Using these data, the curves in Fig. 3 were developed for uniform-graded terraces. It can be seen from these curves that, for a given vertical spacing and land slope, the grade of terrace channel required increases rapidly as the length of the terrace increases. The curves also reveal that terraces up to 300 ft in length require very little grade. Other things being equal, of course, the most efficient terracing is found where comparatively short terraces and low grades exist. For the uniform-graded terrace it would not be necessary to maintain the same size of embankment throughout the length of the terrace, but the embankment could be reduced in size gradually from the lower to the upper end as the drainage area grows less. If a variable grade is used where the grade is increased at intervals along the terrace beginning at the upper end to accommodate the continually augmented runoff from the increasing size of drainage area, then a uniform size of embankment for the terrace is required regardless of length. In Fig. 4 are shown curves for terraces with variable grades similar to the ones in Fig. 3 for uniform grades. It can be seen from the curves that the lengths of a variable-graded terrace that can be used, for a grade of 0.5 per cent at the lower end, are 1,570, 1,280, and 1,100 ft on the slopes of 5, 10, and 15 per cent, respectively, as compared with lengths of 1,210, 970, and 820 ft for terraces with a uniform grade of 0.5 per cent.

A lesser grade may be used at the lower end of a variable-graded terrace than is required for a uniform-graded terrace of the same length, which results in a smaller soil loss. This is due to the fact that a smaller rate of rainfall can be used in its design since, with the lesser grade of the variable-graded terrace, the time required for the water to flow the length of the terrace is greater than for the uniform-graded terrace. For example, a uniform-graded terrace 1,200 ft long on a 5 per cent slope would require a grade of 0.5 per cent at the lower end, while a variable-graded terrace of the same length would require a grade of only 0.3 per cent at the lower end, as indicated in Fig. 5.

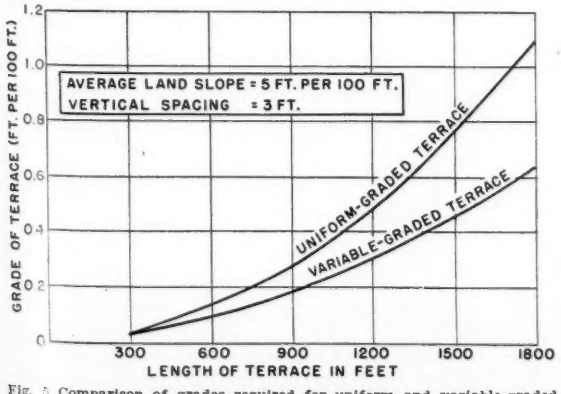
GRADE OF TERRACE (FT. PER 100 FT.)
AVERAGE LAND SLOPE = 5 FT. PER 100 FT.
VERTICAL SPACING = 3 FT.
UNIFORM-GRADED TERRACE
VARIABLE-GRADED TERRACE
LENGTH OF TERRACE IN FEET

Fig. 5 Comparison of grades required for uniform and variable-graded terraces for different lengths

The findings of the experiments at the soil-erosion experiment stations tend to show that the variable-graded terrace is superior to the uniform-graded from the standpoint of conserving both soil and water. The flatter grades near the upper end of the variable-graded terrace tend to store or hold back the upper water until the water below has a chance to flow off. This prevents the concentration or piling up of the runoff water near the outlet end of the terrace so that a lower terrace embankment can be used for a variable-graded terrace under the same field and rainfall conditions without the possibility of overtopping, both types having the same grade at the outlet end. The advantages of the variable-grade over the uniform-grade far outweigh a minor objection, namely, that the variable-graded terrace is slightly more difficult to lay out in the field than the uniform-graded.

Results of the experiments at the erosion-experiment stations indicate that where terraces are properly laid out, well constructed, and carefully maintained, the high factors of safety formerly regarded as necessary for satisfactory terracing work could be safely lowered. This would make it possible to increase the length of terraces over those given in Figs. 3 and 4 for the same grade or to reduce the grade of the terrace if the lengths remain the same.

In the summary of Department Bulletin No. 512 on terracing, the following statement is included: "The instructions given herein for the selection and design of terrace systems are based upon the results of surveys, observations, and a study of terraced fields in the best terraced sections in this country, and it is believed that if they are followed carefully a great increase in the efficiency of terrace systems will result and that a much better opportunity will be afforded to observe the results with a view to further improving the practice of terracing. At the same time a close study of local conditions—particularly of soil—should be made, which no doubt will afford more definite information for improving further the design of a terrace system adapted to a particular locality."

At the time the above paragraph was written it was planned to repeat later the trip through the Southeast to examine terraces that had been designed and constructed in accordance with the information obtained on the original trip. However, when the ten soil-erosion experiment stations were established, beginning in 1929, this furnished an opportunity to conduct experiments needed in order to make an intensive study of the practice of terracing. These studies have disclosed that the original recommendations on terracing have not been appreciably different from the findings on the experiment stations. As a result of these studies, the vertical spacings for graded terraces in the southern part of the country were slightly increased as shown in Fig. 6. It was found that considerable movement of soil took place down the slope and collected in the terrace channel even though all farm operations practically followed the contour. Also it was *(Continued on page 291)*

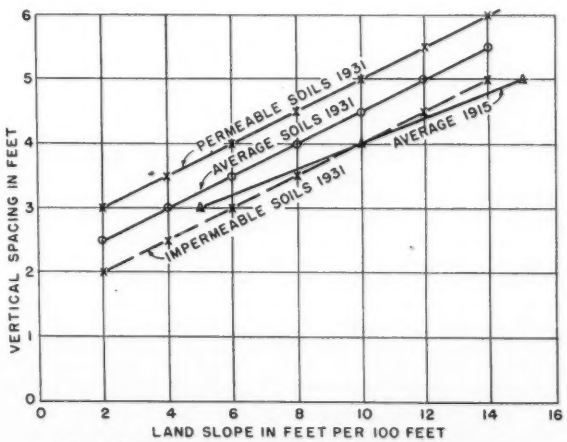

Fig. 6 Terrace spacing recommendations — 1915 and 1931

Gin Fan Power Calculations by Use of a Nomograph

By Arvid J. Johnson

ONE OF the great difficulties which the ginners, salesmen and engineers face in power problems at cotton gins is that of estimating the power consumed by the fans in the outfit. For over a decade, the mimeographed leaflet of the U. S. Department of Agriculture, entitled "Simplified Pitot Tube Calculations of Air Flow in Ducts and Pipes", has been used by the U. S. Cotton Ginning Laboratory and gin fan engineers in their field work. Department Circular 601, entitled "Preventing Power Waste in Operating Cotton Gins," gives detailed information on the construction of the pitot tube and its use and is not repeated here. The purpose of this article is to describe a very simple and recent method of estimating fan power in the field without calculations after pitot tube readings have been taken.

The horsepower required to operate a cotton gin fan is readily determined from the quantity of air the fan is moving and the resistance against which the fan is operating. The two fundamental readings to be made are: (1) P_v, called the velocity pressure from which one may find both the velocity and volume of air moving through the pipe, and (2) P_s, the static pressure or resistance which the piping and the entire system offer to the flow of air. These readings are usually measured in inches of water pressure.

The pitot tube and the manometer are the two essential instruments used in making these air readings on a fan. The pitot tube is inserted in the center of the pipe and connected to the manometer as shown in Fig. 1-A and the P_v is read on the manometer in inches of water pressure. These velocity pressure (P_v) readings may be made either in the suction or discharge side of the fan, but should be taken in a straight run of piping of not less than 7½ diameters, because it requires that much of a straight run to eliminate the effects of eddy currents caused by irregularities in the piping. By means of velocity-pressure readings and volume calculations for various places in the piping layout, the air losses can readily be traced to their source. Static pressure readings (P_s), are used to show the resistance to the flow of air offered by the entire system, which includes the piping, separators and other auxiliary equipment. Such readings can also be made at special points in the system to determine the individual resistance offered by each piece of equipment or its piping. A high degree of accuracy cannot be obtained in readings made at some cotton gins, because of short runs of piping, elbows or other obstructions in the system, but in most cases the readings are accurate enough for practical purposes.

The maximum resistance (P_s) which is used in computing the horsepower for the fan is taken close to the fan and obtained by adding the readings as shown in Fig. 1, B, C, and D, which combines the fan suction and discharge resistance across the fan. The sum of the static pressures and velocity pressure is called the total pressure (P_t) and is used in the formula for calculating the horsepower consumption of the fan.

With these readings, it is possible to determine the velocity, volume of the air in the pipe, and the horsepower used by the fan. The mean velocity in feet per minute in the pipe is equal to $3{,}650 \times \sqrt{P_v}$ for standard air. The volume in cubic feet per minute is equal to the product of the mean velocity in feet per minute times the cross-sectional area of the pipe in square feet. To simplify field calculations, the conversions of these readings to the volume of air handled by the fan for various pressures and pipe sizes are shown in Table 1.

The horsepower of a fan can then be derived by the use of the formula:

$$\text{Horsepower} = \frac{\text{foot pounds per minute}}{33{,}000} = \frac{\text{wt. of air per min.} \times H}{33{,}000} = \frac{\text{cfm} \times w \times H}{33{,}000}$$

Where w = standard air density

H = head in feet of air

$$H = \frac{P_t}{12} \times \frac{62.3}{w}$$

Where 62.3 = density of water and P_t is in inches of water

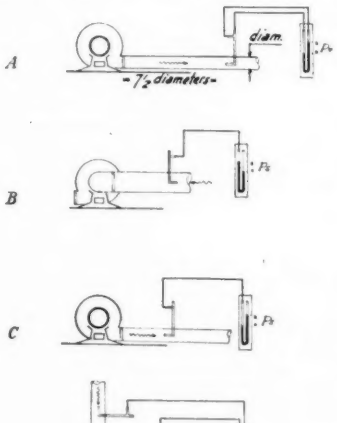

Fig. 1 Diagram illustrating the use of a pitot tube and manometer in making air readings: A, velocity pressure (P_v); and B, C, and D, static pressure (P_s) —for fans used for suction only (B), for blowing only (C), and for both suction and blowing (D)

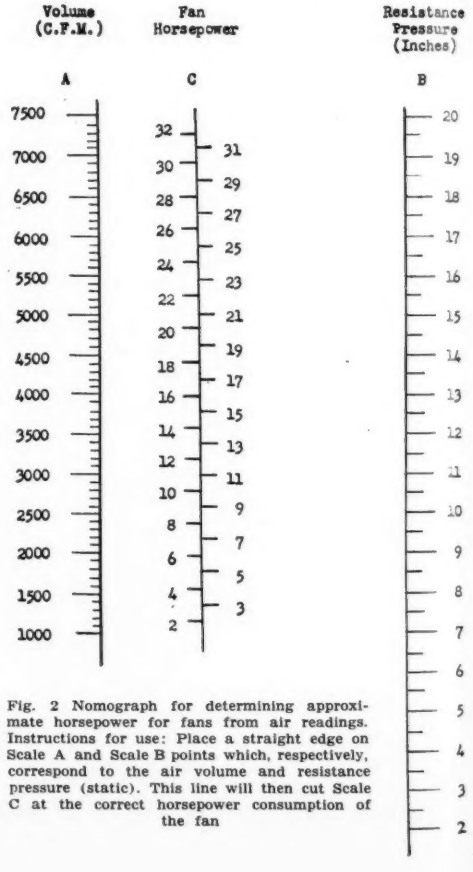

Fig. 2 Nomograph for determining approximate horsepower for fans from air readings. Instructions for use: Place a straight edge on Scale A and Scale B points which, respectively, correspond to the air volume and resistance pressure (static). This line will then cut Scale C at the correct horsepower consumption of the fan

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TABLE 1. VELOCITIES AND VOLUMES CORRESPONDING TO P_v READINGS AND PIPE DIAMETER[1]

P_v	$\sqrt{P_v}$	Vel.	Cross Sectional Area and Pipe Diameter *														
			.4418	.4922	.5454	.6013	.6600	.7215	.7854	.8522	.9218	.9940	1.069	1.147	1.227	1.396	1.576
			9	9½	10	10½	11	11½	12	12½	13	13½	14	14½	15	16	17
.1	.32	1168	516	575	637	702	771	842	917	995	1077	1161	1249	1340	1433	1630	1841
.2	.45	1642	725	808	895	987	1084	1185	1290	1400	1514	1633	1756	1884	2016	2293	2588
.3	.55	2008	887	988	1095	1207	1325	1448	1577	1710	1851	1995	2146	2302	2463	2802	3164
.4	.63	2300	1016	1132	1254	1383	1518	1659	1806	1959	2120	2286	2458	2637	2822	3210	3624
.5	.71	2592	1144	1276	1414	1559	1710	1869	2036	2208	2389	2576	2770	2972	3180	3618	4084
.6	.77	2810	1241	1383	1533	1690	1855	2027	2208	2395	2591	2794	3004	3223	3448	3923	4429
.7	.84	3066	1354	1509	1672	1844	2024	2212	2408	2612	2827	3048	3278	3516	3762	4280	4832
.8	.89	3248	1435	1599	1772	1953	2144	2343	2552	2768	2995	3229	3473	3725	3986	4534	5119
.9	.95	3467	1531	1706	1891	2085	2289	2501	2724	2954	3197	3447	3707	3977	4255	4840	5464
1.0	1.00	3650	1612	1797	1991	2195	2409	2633	2867	3110	3365	3628	3902	4186	4479	5095	5752
1.1	1.05	3832	1693	1886	2091	2304	2529	2765	3010	3265	3533	3809	4097	4395	4703	5350	6039
1.2	1.10	4015	1773	1976	2170	2414	2650	2896	3154	3421	3701	3991	4292	4605	4927	5604	6328
1.3	1.14	4161	1838	2048	2270	2502	2746	3002	3268	3545	3836	4136	4448	4772	5106	5808	6558
1.4	1.18	4307	1902	2120	2349	2590	2843	3111	3383	3670	3971	4281	4604	4939	5285	6012	6788
1.5	1.22	4453	1967	2192	2429	2678	2939	3212	3498	3794	4105	4426	4760	5107	5464	6215	7018
1.6	1.26	4599	2031	2264	2508	2765	3035	3318	3612	3919	4240	4571	4916	5274	5644	6420	7248
1.7	1.30	4745	2096	2335	2588	2853	3132	3423	3727	4043	4374	4716	5073	5442	5823	6623	7478
1.8	1.34	4891	2160	2407	2668	2941	3228	3528	3842	4167	4509	4862	5229	5609	6002	6827	7708
1.9	1.38	5037	2225	2479	2748	3029	3324	3634	3956	4292	4644	5007	5385	5777	6181	7031	7938
2.0	1.41	5146	2273	2533	2807	3094	3397	3713	4042	4385	4745	5115	5502	5902	6315	7184	8110
2.1	1.45	5292	2337	2605	2887	3182	3493	3818	4157	4509	4879	5261	5658	6070	6495	7388	8340
2.2	1.48	5402	2386	2659	2947	3248	3565	3897	4243	4603	4980	5369	5775	6195	6629	7541	8514
2.3	1.52	5548	2450	2731	3026	3336	3662	4002	4358	4727	5114	5515	5931	6363	6808	7744	8744
2.4	1.55	5658	2499	2785	3086	3402	3734	4081	4444	4820	5216	5623	6048	6488	6942	7897	8917
2.5	1.58	5767	2547	2839	3146	3468	3806	4160	4530	4914	5317	5732	6165	6614	7077	8050	9089
2.6	1.61	5876	2596	2892	3205	3533	3878	4240	4615	5008	5416	5841	6281	6740	7210	8203	9260
2.7	1.64	5986	2644	2946	3265	3599	3951	4319	4701	5101	5518	5950	6399	6866	7345	8356	9434
2.8	1.67	6096	2693	3000	3325	3666	4023	4398	4788	5195	5619	6059	6517	6992	7480	8510	9607
2.9	1.70	6205	2741	3054	3384	3731	4095	4477	4873	5288	5720	6168	6633	7117	7614	8662	9779
3.0	1.73	6314	2790	3108	3443	3797	4167	4556	4959	5381	5820	6276	6750	7242	7747	8814	9951

1/. Velocity = 3650 $\sqrt{P_v}$; volume = velocity times cross-sectional area of pipe

* Cross-sectional area of 6" = .1964; 8" = .3491; 8½" = .3941; 18" = 1.767; 19" = 1.969; 20" = 2.182

$$\text{Horsepower output} = \frac{\text{cfm} \times w \times P_t \times 62.3}{33{,}000 \times 12 \times w}$$

$$\text{A H P} = \frac{\text{cfm} \times P_t}{6356}$$

$$\therefore \text{Horsepower of fan} = \frac{\text{Volume} \times P_t}{6356} \times \text{efficiency factor}$$

This horsepower is the power required to operate a fan having 100 per cent efficiency. The actual or brake horsepower is then obtained by multiplying the theoretical horsepower by an efficiency factor. Tests at the U. S. Cotton Ginning Laboratory have shown that it will be sufficienty accurate for field use in determining the approximate horsepower to multiply the theoretical horsepower by three for Rembert-type fans and by two for the other commonly used gin fans.

To obtain the power consumption of gin fans involves considerable calculations and the simple nomograph (Fig. 2) has therefore been prepared for use with Table 1. Thus when the volume in cubic feet of air per minute and the resistance pressures across the fan are both known, a straight edge placed upon the nomagraph scale A and B at those points will cut scale C at the correct horsepower point. This gives close enough results for most ginners, power engineers and fan specialists.

Developments in Terrace Spacing

(Continued from page 289)

found that the badly eroded or more impermeable soils eroded faster than the virgin or more permeable soils. In order to provide for this difference in the erodibility of different soils, it will be seen from Fig. 6 that an additional ½ ft was allowed in the vertical spacing of terraces on permeable soils and a reduction of ½ ft was recommended for terraces on impermeable soils. From this figure it will be seen that the 1931 curve for impermeable soils nearly coincides with the 1915 recommendations for average soils. The experiment-station results indicate that no appreciable increase can be made in these spacings without an unduly large amount of erosion resulting if row crops are continued in the farm rotation.

GENERAL SUMMARY ON TERRACE SPACING

1 Results of experiments obtained at the erosion-experiment station indicated that spacing of terraces for average soils in the Southeast, as recommended in 1915, could be slightly increased with allowance for wider spacing on permeable soil and narrower spacing on impermeable soil, without unduly increasing erosion losses.

2 The recommendations given in Farmers' Bulletin 1669 were based upon investigations made in 1915 and modified in accordance with results of experiments on the ten original soil-erosion experiment stations, and are essentially the same as recommendations given in Farmers' Bulletin 1789 now in use. Experiment-station results show that these spacings cannot be materially increased without exceeding reasonable limits recognized for soil losses in an effective soil-conservation program.

3 Where so-called diversion terraces with wide spacings are employed, which are essentially diversion or intercepting ditches draining comparatively large areas, the cross section and grade of the ditch or channel must be carefully determined by means of runoff and channel-flow formulas so as to handle the runoff from the known drainage area. This will insure against the possibility of the channel capacity being exceeded thus causing a break and excessive erosion on the land slope below. Such ditches should be seeded to grass to control erosion and should be mowed occasionally to prevent reduction in discharge capacity.

Predicting Changes in Water-Table Elevation in Peat Land

By M. B. Russell

THE position of the ground-water surface in organic soils has a marked influence on the growth of crops on those soils[2*]. In designing drainage or irrigation systems for controlling the elevation of the water table in such soils, it is of interest to know how far the water table will rise or fall at any given depth, following the addition or removal of a known amount of water from the profile. To predict the behavior of the water table following the addition or removal of water, it is necessary first to determine the volume of water-filled pores at all points between the water table and the soil surface. Having established the vertical distribution of water-bearing pores, it is a simple matter to determine how far the water table will rise or fall in response to the addition or removal of a known amount of soil water.

The volume of water-filled pores at any point above the phreatic surface can be determined readily from a moisture-sorption curve[4]. Such a curve represents the equilibrium moisture content at different distances above a free water surface. An apparatus for determining moisture desorption curves of soil samples having undisturbed structure has been described[3]. Since the moisture-storage characteristics of the entire profile are desired, it is necessary to determine moisture-sorption curves for samples having undisturbed structure taken from several depths.

Method of Calculation Used. The method used in calculating the effect of added water on the water-table elevation can best be illustrated from the idealized sorption curves shown in Fig. 1. Assume that A, B, C, and D. represent the moisture-sorption curves of the first, second, third and fourth foot sections, respectively, of a peat profile. From curve B, for example, it is seen that the equilibrium moisture content at the 1 to 2-ft depth is 78 per cent when the center of this section is 2.5 ft above the free water surface, i.e., when the water table is 4 ft below the soil surface. If the water table is raised one foot, curve B shows that the moisture content of the 1 to 2-ft section will increase to 80 per cent. The increase of 2 per cent in the volume occupied by water would require 0.24 surface inches of additional water for the 1-ft section of soil.

This interpretation of the sorption curves assumes that the moisture content within the section represented by the curve changes linearly in a vertical direction through the section. Obviously such is not the case, but the error incurred in making this assumption can be minimized by reducing the thickness of the section that is to be represented by a particular sorption curve. Such a procedure, of course, increases the number of curves needed to characterize a given profile.

It has been shown that an appreciable hysteresis exists between absorption and desorption curves[1]. For this reason curves of the type shown in Fig. 1 should be made from desorption data if the effect of drainage on water-table elevation is to be predicted. If, however, we wish to determine the effect of rainfall or irrigation on the position of the water table, the calculations should be made from curves constructed from absorption data. Since A, B, C, and D in Fig. 1 are merely idealized curves, the interpretation of data calculated from them can be in terms of the effect of either the addition or removal of water from the profile.

By referring to curves A, C, and D we find that for the surface foot the volume of moisture changes from 61.6 to 64.0 per cent as the result of raising the water table from 4 to 3 ft. For the soil in the third and fourth-foot sections such a change causes the moisture to increase from 73.3 to 78.0 per cent and from 69 to 72 per cent, respectively. Thus we see that 0.29 in, 0.24 in, 0.56 in, and 0.36 in more water will be held in the 0 to 1-ft, 1 to 2-ft, and 3 to 4-ft sections, respectively, when the water table is 3 ft below the soil surface than when it is a foot lower. Therefore it follows that the addition of 1.45 in of water to this soil would cause a one-foot rise in the water table if it were originally at the four-foot depth.

Similar calculations may be made of the amount of additional water required to raise the water table from the three to the 2-ft depth, from the two to the 1-ft depth and from the 1-ft depth to the surface. If an accumulative curve of these values is drawn, it may be used to predict the change in water-table elevation that will follow either the addition to or removal from the soil of a known amount of water.

Results and Discussion. Soil samples having undisturbed structure were taken at 6-in intervals to a depth of 4 ft from each of five sites on the large cultivated peat area at the Crystal Lake Experimental Farm. Desorption curves were determined on each of these samples. From these curves calculations of the type described above were made and were used to construct the curves shown in Fig. 2. The behavior of samples from sites 1, 2 and 3 was so similar that these three sites are represented by a single curve. At sites 4 and 5, however, the depth and degree of compaction of the peat were sufficiently different to cause the curves for these sites to deviate from those of sites 1, 2 and 3. These curves indicate that the removal of equal quantities of water can be expected to lower the water table by different amounts at different parts of the peat area. From Fig. 2 it can be seen that at site 1 it is necessary to remove 1.8 in of water to lower the water table one foot from the 2-ft depth, whereas the removal of 1.0 in of water will accomplish the same change at site 5.

The fact that the slope of the curve representing site 5 is considerably greater than that of the curve for site 1 indicates that at the former location the peat profile is poorer in the large size pores which drain under low tension than is the soil at site 1. Thus at site 5 a smaller number of these non-capillary pores must be drained when the water table is lowered than is necessary at site 1.

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and published as Journal Paper No. J-1281 of the Iowa Agricultural Experiment Station, Project No. 880.

M. B. RUSSELL was research associate professor of agronomy, Iowa State College, and agent, division of research, Soil Conservation Service, U. S. Department of Agriculture, at the time of writing this paper, but is now on the agronomy staff at Cornell University.

* Superscript numbers refer to literature cited at end of paper.

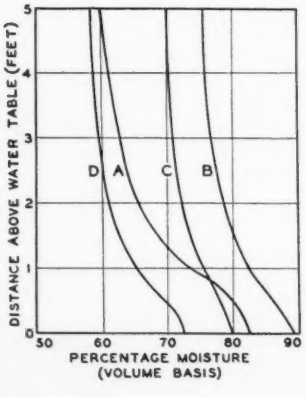
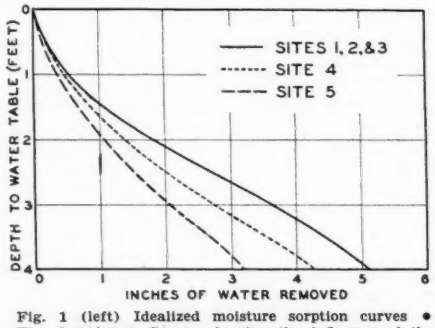


Fig. 1 (left) Idealized moisture sorption curves • Fig. 2 (Above) Curves showing the influence of the removal of water upon the position of the water table at five sites at the Crystal Lake (Iowa) Experimental Farm.



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4 Russell, M. B. The utility of the energy concept of soil moisture. Proc. Soil. Sci. Soc. of Amer. 7:90-93 (1942)

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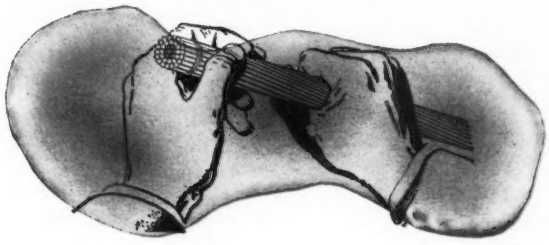

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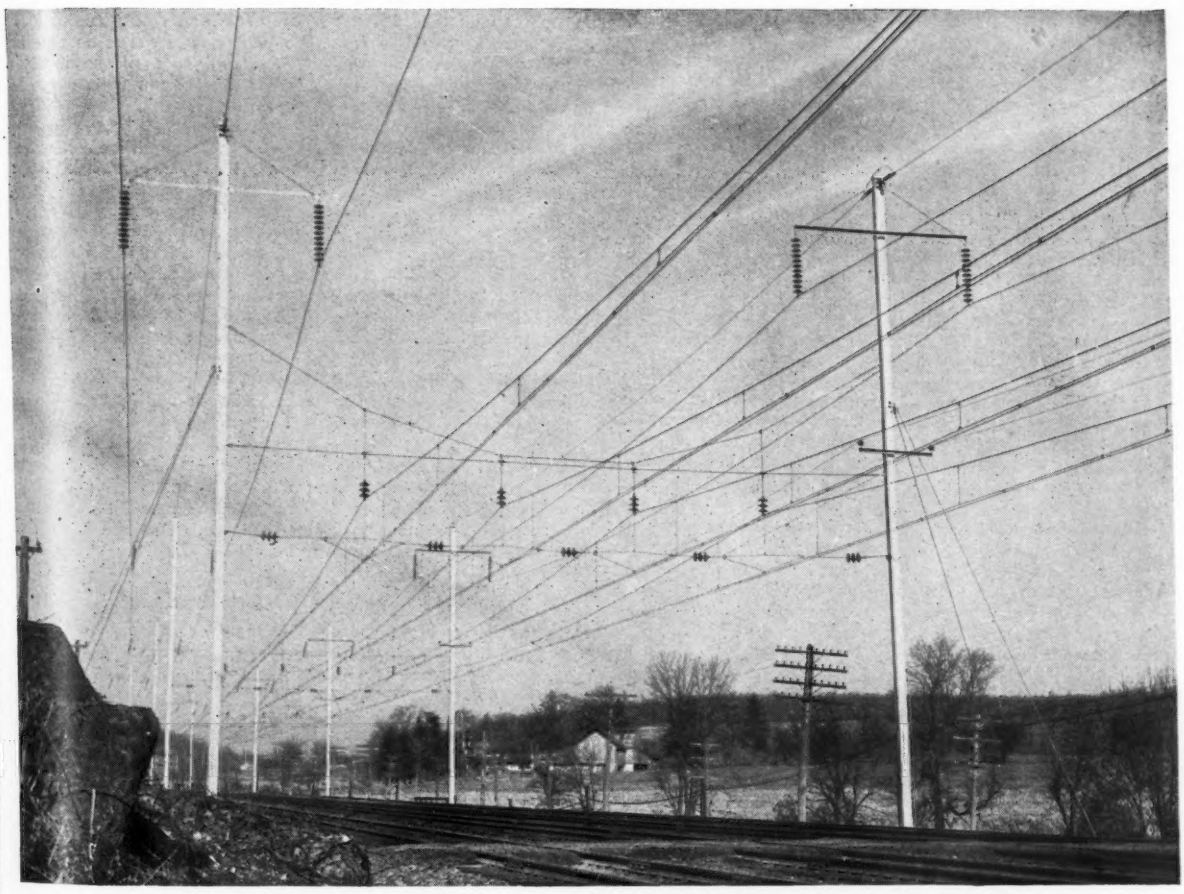

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Problems in Indian Agriculture

By Mason Vaugh
ASSOCIATE A.S.A.E.

MANY members of the agricultural engineering profession are now serving in the armed forces, some of them in tropical countries and concerned with agriculture, and there have been proposals for the employment of some of these engineers in various postwar activities in other countries. Also, current world news tends to stimulate new interest, in foreign peoples, foreign agricultural practices and related subjects. All this has prompted the following statement about certain practices and implements now being tried out at Allahabad, India.

The climate of India is subtropical. The country lies partly in and partly out of the tropics. At Allahabad, the agricultural year begins with the arrival of the monsoon, about July 1st. July, August and September are the rainy season with a rainfall of about 35 to 40 in. October to March is cooler with some light frost in January or early February and an average of about 2 in of rainfall during the period. April, May and June are hot and dry, with temperatures going up to 115 deg or more maximum, and very little or no rainfall. The useful rainfall is mostly concentrated in the three months of July, August and September.

Summer crops—sorghums, millets, maize, pulses, and rice—are planted with the arrival of the monsoon. Winter crops—wheat, barley, pulses, and vegetables such as potatoes—are planted in October and November and harvested mostly in March and April. Early seeding in the beginning of the rainy season is important. Winter crops are sown, for the most part, a month to six weeks after the end of the rainy season. About 25 per cent of the area is irrigated, and the rest is dependent on the moisture stored.

To avoid the very high peak demand for labor in the beginning of the rainy season, we found it desirable to plow all land during the dry weather of March to June. The soil is alluvial, deep and varies from sandy to clay loam. Especially when deficient in organic matter it gets very hard on drying. Experimentation showed that it was not necessary to pulverize land plowed at this season. If broken up into large clods and allowed to lie, a good seedbed could be made with simply spring-tooth harrowing just after a good shower. The cloddy surface tended to hold the first rain well which is often very heavy and falls at a high rate.

Moldboard plows did not work well. Designed to pulverize as well as invert, they required much power and wear on the plows was excessive. The need of a different implement was thus indicated. After trying various things, an implement which was essentially a double-moldboard plow — a middlebreaker — was devised with a share which was essentially the same as a middlebreaker share with the wings clipped off to leave about 6 in width of the center of the original share. The moldboards were removed Worked at furrow distances of about 9 in, this implement effectively broke up the soil to a depth of about 6 to 8 in, turning over some of the clods and leaving a rough surface from which soil did not blow, on which organic matter was trapped, and which held all of the water from rains up to a couple of inches in an hour or two. While carefully controlled yield tests were not made, it generally appeared that they were certainly not less than those secured by waiting till rain fell and then plowing. Over a period of years yields have risen, sometimes to double previous yields.

Common practice is to follow a two-year rotation in which summer crops are grown on approximately half the land and winter crops on the remainder, reversing the plots every other year. The land was low in organic matter and available nitrogen so the growing of a green manuring crop on the fallow land in the rainy season was desirable. Crotalaria juncea is an excellent crop for the purpose, adding 40 to 60 lb of nitrogen to the acre. Preparing a seedbed and sowing it in the usual way competed for time and labor with the other crops and usually did not get done until too late. Experiment showed that the seed could be broadcast among the clods before the rains actually began; the seed did not suffer from the hot soil, and birds did not eat it. It was sufficiently covered when the clods melted somewhat due to the rain. The rough surface helped early and deep penetration of moisture. The crop of green matter so secured was in no way inferior to that from a well-prepared seedbed. The total labor required was the scattering of the seed by broadcasting, which could be done at a slack time before the monsoon arrived. The crop was ready to turn under at the time when the land must be plowed anyway in order to keep down weeds and volunteer growth in preparation for fall seeding, about the middle of August.

Success with the green-manuring procedure led to experiments with seeding sorghum which is the major summer fodder and grain crop. Standard practice in the villages is to plow shallowly with the wooden plow several times after rain falls, broadcast the seed and plow it in with a final plowing. Practice at the Institute had been to plow in the dry weather, prepare the seedbed by harrowing once or twice with spring-tooth harrows, broadcast the seed by hand, and cover it with another spring-tooth harrowing. This put the seed in to what would ordinarily be considered an ideal seedbed. However, if heavy rain fell just after seeding, followed by sunny weather, undesirable crusting occurred. We wished to substitute sowing in rows to facilitate machine cultivation instead of hand weeding previously practiced. Trials showed that by closing spouts to give the desired row spacing, it was possible to sow the sorghum seed in rows with ordinary grain drills, entirely without further seedbed preparation after rough plowing. Hoes not used are generally removed to lighten draft. In friable loam soils, the grain drill hoes broke up the clods enough to cover the seed satisfactorily. Leaving the middles rough facilitated rapid absorption of rainfall so that it was safe to seed after only half an inch to an inch of rain. Seeding is rapidly carried out as no time is lost in preparing the seedbed. The drill hoes kill germinating weeds so that the rows show clearly as the weeds start in the middles, enabling the first interculture to start as soon as the seeding is finished. If harrowing is desired as the first interculture operation, the rough condition of the soil makes it much more effective than on soil which has been harrowed down fine and then compacted by several rains.

While carefully controlled yield tests have not been made, the method has been used through three seasons. Judging by the number of loads harvested from a field, the yield has not been reduced. In fact, in one season when the rainfall was subnormal by nearly half, the best crop on the farm was an experimental field seeded by this method. It was considered at least as good as that expected with normal rainfall. The advantages in labor saving and getting in the crop promptly would justify the use of the method even if the yield was slightly reduced; indications are that it will average over a period in increasing rather than in reducing yields of sorghums of the kaffir corn-milo maize type.

These results have led us to question many of the soil management practices in use. The agricultural engineering department has been given an area of 40 acres which is being used to test small implements and farm practices of this sort, particularly in relation to the farmer having a small area under cultivation. This has just been started and results from it are not yet available.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.
MASON VAUGH is head, agricultural engineering department, Allahabad Agricultural Institute (India).

"Red Schoolhouse Ceiling"

TO THE EDITOR:

THE editorial "Red Schoolhouse Ceiling" in the June issue of AGRICULTURAL ENGINEERING attacks the problem from the educational viewpoint. More power to the writer thereof and to all educators. I would that the educational level be raised to the *n*th degree.

Having worked with farmers and tractor operators for many years, I have become conscious of their capacities and limitations. As a general rule, these people earn their living by working with their hands. Their thought processes are attuned to hand and body movements. More favorable results are obtained when instructions are given in terms of physical processes rather than abstractly. To speak abstractly is to waste time. To illustrate graphically the step-by-step procedure—and I mean *step-by-step*—is to get favorable results.

Printed material intended for farmer consumption is too often lacking in the A, B, C approach. Preparing such material is the most difficult of all editorial work.

No one has a greater respect and admiration for the farm operator than I. His total knowledge is great. It covers many fields of science and art. He works hard. But he does have definite limitations in the matter of translating printed instructions into plans and action. Since the A.S.A.E. membership includes many in educational work, both in private industry and public service, I suggest that the Society journal is an appropriate medium for dealing with this subject.

W. A. HARPER

Help make his HOME *secure . . .*

MOST farm homes have been neglected for the past twenty years, quite as much as have farm buildings. This has resulted in unwarranted deterioration.

One of the many ways you can be of service to farmers today is by reminding them of the lost values and comforts which are caused by the lack of a good home-maintenance program.

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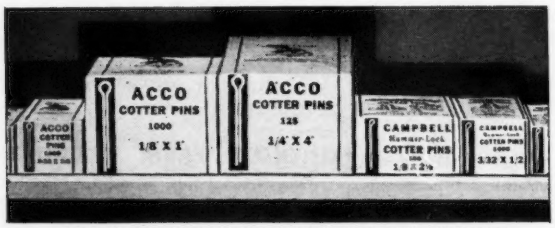

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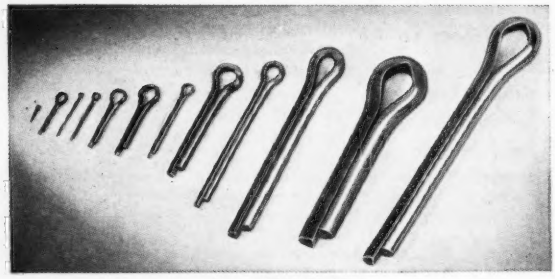

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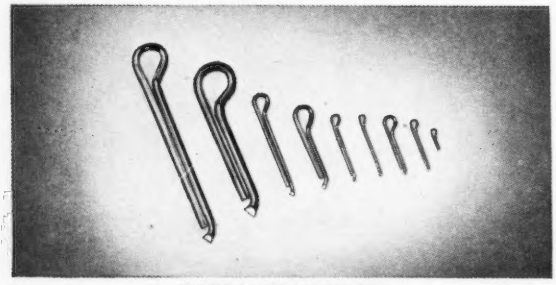

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NEWS SECTION

Washington Section Completes Season

THE Washington, D. C., Section of the American Society of Agricultural Engineers, at its meeting June 14 in the USDA South Agricultural Building, completed a most successful season of monthly meetings starting last October.

A special feature of the meeting was the awarding of a framed certificate designating honorary membership in the Society to Hon. Claude R. Wickard, Secretary of Agriculture. In the absence of the President of the Society, Dr. R. W. Trullinger, assistant chief, USDA Office of Experiment Station, was delegated by the President to make the presentation of the certificate in the name of the Society to Secretary Wickard.

Following this presentation Section members and friends listened with a great deal of interest to a talk by Dr. L. G. Michael, agricultural attache of the United States Embassy at Moscow. In his talk, Dr. Michael briefly outlined the historical background of the idea of collective farming in Russia and described its present organization. He briefly discussed the machine and tractor stations which rent machinery to the collective farms, the repair shops and the large district machine shops, all of which, together with the "kolkhoz", form the system of collective farming.

A short business session was held toward the end of the meeting at which the following Section officers were elected for the ensuing year: Chairman, E. M. Dieffenbach, farm machinery and equipment division, War Food Administration; vice-chairman, Dr. Ross E. Moore, Office of Foreign Agricultural Relations, USDA, and secretary-treasurer, J. W. Simons, chief, farm building section, War Food Administration.

Chicago Section Features Farm Refrigeration

KEEN interest was indicated by the unexpectedly large attendance which gathered for the discussion of the subject "Engineering Farm Refrigeration," which formed the one and only topic for a meeting of the Chicago Section of the American Society of Agricultural Engineers held at the Stevens Hotel, Chicago, on June 5. The program opened with a paper on the subject by J. P. Schaenzer, acting head of the special problems section, technical standards division, Rural Electrification Administration. Following Mr. Schaenzer's paper the subject was discussed from various angles by a discussion panel, which included in addition to Mr. Schaenzer, George H. Foster, Purdue University; Dr. Frank Gougler, Illinois Agricultural Assn.; E. W. Lehmann, University of Illinois; D. J. McGinnis, J. G. Leser Co.; E. H. Parfitt, Evaporated Milk Assn.; Ruth Whiting, International Harvester Co.; D. W. Wiant, Michigan State College, and M. L. Wilson, Babson Brothers Mfg. Co.

The program was arranged by a program committee consisting of D. G. Womeldorff (chairman), Walter H. Lloyd and E. L. Hansen, and preceded the A.S.A.E. Annual Dinner held the same evening.

Wickard Is New REA Administrator

HON. CLAUDE R. WICKARD, recently elected an honorary member of the American Society of Agricultural Engineers, has been appointed by President Truman as the new administrator of the Rural Electrification Administration, a position for which he is eminently qualified.

Personals of A.S.A.E. Members

Roy Bainer, professor of agricultural engineering and agricultural engineer in the agricultural experiment station, University of California, is on leave from his duties for three months at the request of the British Ministry of Agriculture and Fisheries to assist British agencies with problems involved in the mechanization of sugar beet production. He will be associated with the mechanical development board and the mechanical operations division of the Ministry of Agriculture.

E. J. Hergenroether, who has been in Washington serving with the War Production Board and agencies preceding it since May, 1941, recently resigned as chief of the metallurgical branch, steel division (WPB), to resume his duties with the development and research division of the International Nickel Co. He will be in

(Continued on page 298)

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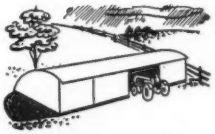

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Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Tate T. Brady, S/Sgt., 377 Inf., USA. (Mail) APO 95, c/o Postmaster, New York, N. Y.

Paul A. De Leon, Jr., mechanical engineer, animal food division, Cleaver-Brooks Co. (Mail) 227 E. Townsend St., Milwaukee 11, Wis.

Dwight H. Early, western advertising representative of Agricultural Engineering, 100 N. La Salle St., Chicago 2, Ill.

Emil W. Eliason, Lt., Naval Training School (diesel engineering), USNR. (Mail) 924 S. Kernan Ave., Appleton, Wis.

S. M. Elliott, manager of testing, tire division, B. F. Goodrich Co., 500 S. Main St., Akron, Ohio.

Howard C. Esbeck, design and development engineer, John Deere Spreader Works of Deere and Co. (Mail) 409 - 2½ Avenue, Silvis, Ill.

Frederico Jose de Souza Rangel, president, Companhia de Expansao Economica Fluminense, Rio de Janeiro, Brazil. (Mail) Av. Bartolomeu Mitre, 537.

George R. Stafford, engineering aide, Bureau of Plant Industry, Soils and Agricultural Engineering, USDA. (Mail) Colorado State College, Fort Collins, Colo.

Frank M. Toperzer, field engineer, Portland Cement Association. (Mail) P. O. Box 6, Medford, Mass.

Ruth D. Whiting, director, home economics laboratory, International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill.

Max B. Williams, pproject engineer, David Bradley Mfg. Works. (Mail) 285 N. Hobbie Ave., Kankakee, Ill.

TRANSFER OF GRADE

Reuben R. Garrard, Lt., 1360 Base Unit, ICD-ATC, AAF. (Mail) R.F.D. 3, Washington, Ga. (Junior Member to Member)

Keith H. Hinchcliff, assistant professor of agricultural engineering, University of Illinois, Urbana, Ill. (Associate to Member)

Marvin Isvik, foreman, machine shop, Aeromotor Co., Chicago, Ill. (Mail) 5451 Washington Blvd. (Junior Member to Member)

J. A. Vorster, lecturer and research officer, University of Pretoria, Pretoria, South Africa. (Junior Member to Member)

Personals of A.S.A.E. Members

(Continued on page 296)

charge of the division's automotive steel development and will make his headquarters att the company's field office in Detroit.

George E. Mullen, Jr., has been appointed manager of the farm sales division of the appliance and merchandise department of the General Electric Company at its Bridgeport, Connecticut, plant.

Russell L. Perry, associate professor of agricultural engineering and associate agricultural engineer in the agricultural experiment station, University of California, is on leave for a special assignment as consultant to the U. S. Army Quartermaster Corps in Europe. His mission is concerned with food-processing equipment and practices.

R. A. Schmidt is now farm service engineer for Imperial Oil Company, Ltd., in the Province of Saskatchewan, Canada. He spent four years with the Royal Canadian Air Force serving for three years overseas in Great Britain and Africa. At the time of his discharge he held the rank of flight lieutenant.

John P. Seaholm is retiring as chief experimental engineer at the Moline, Illinois, plant of the Minneapolis-Moline Power Implement Company. Having served this company and its predecessors for more than a quarter of a century and having made many important agricultural engineering contributions in the design of farm implements and machines for tractors use, his interest henceforth will be devoted largely to his large farm near Erie, Illinois.

Charles C. Worstell is now senior design engineer, Rock Island Works, J. I. Case Company. He was formerly employed as an engineer at the Moline Tractor W ..ks of Deere & Co.

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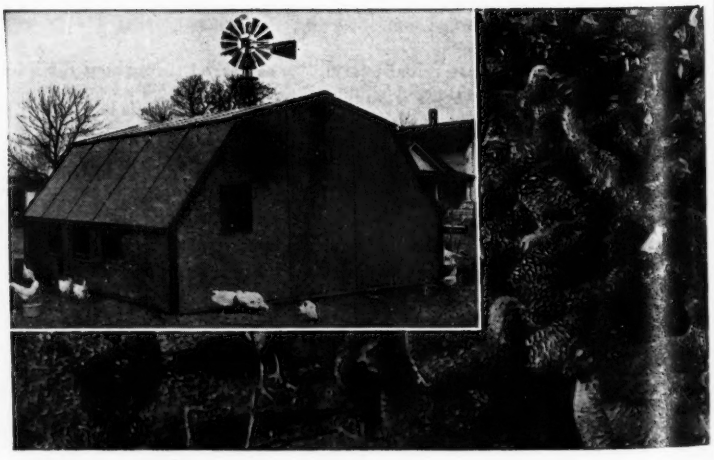
Masonite Corporation farm engineers are at your service, to consult with you on the application of durable Presdwood—a lignocellulose product of exploded wood fiber. Plans for farm structures are yours for the asking. Write Masonite Corporation, Dept. AE-7, 111 W. Washington St., Chicago 2, Ill.



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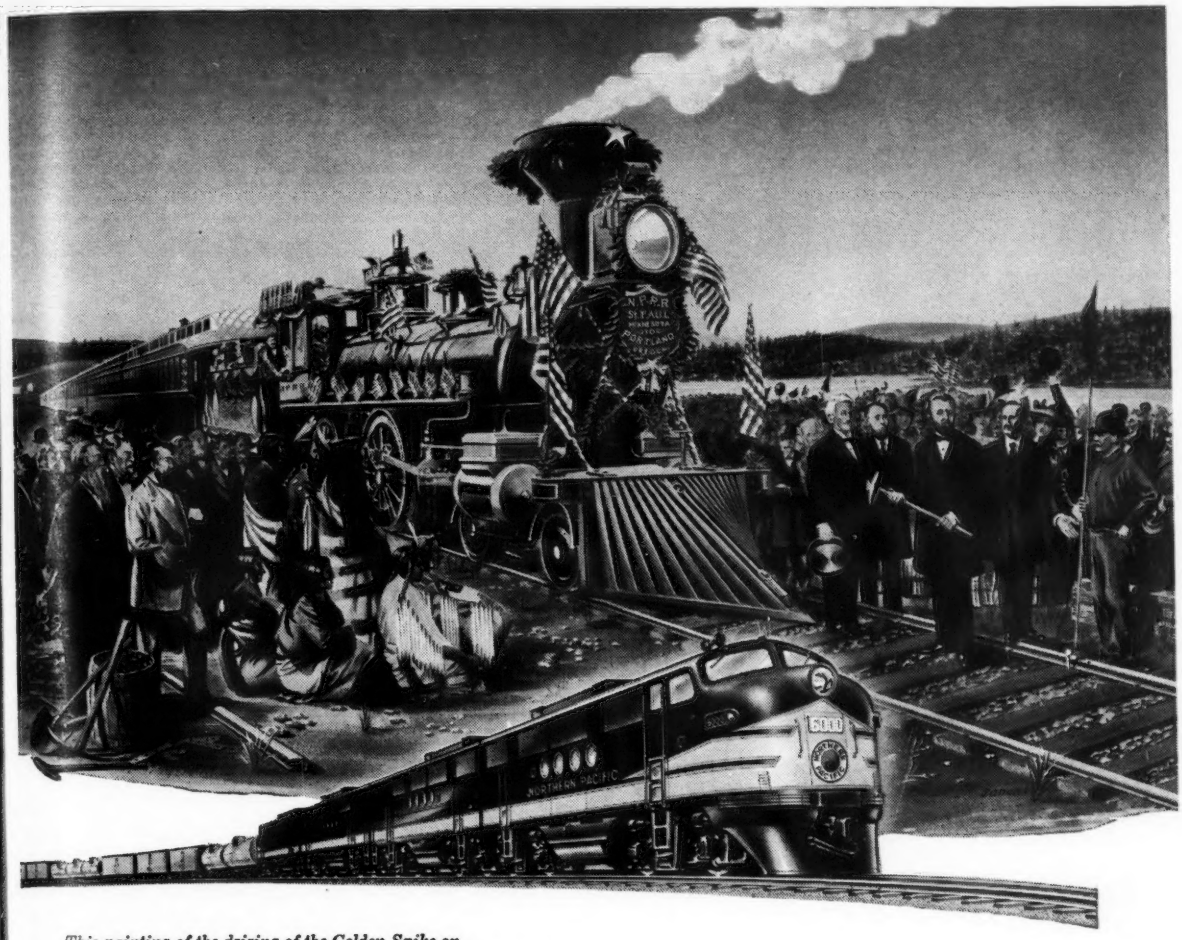

This painting of the driving of the Golden Spike on September 8, 1883, is a composite, in Currier & Ives style, of an actual photograph of the historic engine and a mural now decorating the Montana State Capitol in Helena.

WRITING NEW RAILROAD HISTORY

Sun glinting on yellow metal marked a great moment in railroad history that day in September, 1883. At Gold Creek, Montana, General U. S. Grant drove home a golden spike — and the Northern Pacific, first of the northern transcontinental railroads, was completed.

Shortly after, a special train puffed over the spot, carrying officials and distinguished guests from the East and Europe, on the first through train trip from St. Paul to Portland, Oregon.

History is still being made on the Northern Pacific, as great trains of battle-bound freight hurry westward in support of fighting forces.

For here mighty GM Diesel freight locomotives are writing a brilliant record of accomplishment over steep and twisting mountain grades.

Hauling greater tonnages faster and at lower cost, they are showing today what tomorrow can bring when whole lines are GM Dieselized. Then this momentous power will usher in an era when freight will travel faster, passengers ride with greater comfort, speed and luxury, and the whole land benefit from lower railroading costs.

ON TO FINAL VICTORY
BUY MORE WAR BONDS

GM
GENERAL MOTORS
DIESEL POWER

LOCOMOTIVES . . . . . ELECTRO-MOTIVE DIVISION, La Grange, Ill.

ENGINES . . 150 to 2000 H.P. . . CLEVELAND DIESEL ENGINE DIVISION, Cleveland 11, Ohio

ENGINES . . . 15 to 250 H.P. . . . . DETROIT DIESEL ENGINE DIVISION, Detroit 23, Mich.

Screeding layer of Zonolite Insulating Concrete over old floor of pen in hog house.

Row of farrowing pens with 3-inch Zonolite Insulating Concrete installed over old floor.

Talk ZONOLITE INSULATION

and you talk increased egg, milk and pork production!

INSULATING THESE BUILDINGS PAYS BIG DIVIDENDS!

DAIRY BARNS

LAYING HOUSES

MILK HOUSES

FOR HOME COMFORT

You know how warm, dry floors in hog houses reduce farrowing losses—how warm, dry poultry houses increase egg production—and how warm, dry dairy barns increase milk and butter fat production during winter months. *Talk Zonolite* and you talk increased profits for your farmers.

Zonolite is a mineral insulation. It is rot-proof, fireproof, rodent proof, termite proof, odorless, a non-conductor of electricity and chemically inert. It comes in three forms.

Zonolite Granular Fill is poured from the bag like popcorn, and is used to fill sidewalls and ceilings of poultry houses, hog houses and dairy barns as well as homes.

Zonolite Concrete Aggregate is mixed with cement and water to make warm, dry floors and walls in all types of farm buildings housing livestock and poultry.

Zonolite Plaster Aggregate is used instead of sand to make a plaster that insulates against cold, heat and sound. It resists cracking and will not flake when nails are driven in it.

Let us send you complete details and a set of work sheets showing how Zonolite Insulation is installed in various types of farm buildings. Mail coupon.

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ZONOLITE INSULATION
Permanent as the Earth Itself

Universal Zonolite Insulation Co., Dept. AE-75
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Chicago 3, Ill.

Please send me complete details about Zonolite Insulation and a set of Free work sheets.

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Address.....

City.....*State*.....

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any Notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

IRRIGATION ENGINEER wanted to take charge of experimental work on the irrigation station of a land-grant college in a north central state. Salary about $3400. Write giving full details of education and experience. PO-190

MECHANICAL ENGINEERS wanted for the mechanical development and designing of corn pickers, combines, other implements, and tractors. Permanent position with old, well-established Wisconsin manufacturer with world-wide distribution. Postwar markets assure big future in farm equipment. All inquiries will be acknowledged. PO-189

AGRICULTURAL ENGINEER wanted by national organization to act as field representative in farm building field in Michigan. Sales promotion and service work with no sales. Straight salary. Position will entail travel with expenses paid. PO-188

AGRICULTURAL ENGINEER, preferably with some sales experience in the building materials or construction field, or some extension experience in farm structures, wanted by a nationally known manufacturer of building materials to do educational, research and promotional work in the Middle West with headquarters in Chicago. Excellent opportunity for permanent postwar connection with a well-established, substantial manufacturing organization. Salary open. State education, experience, draft or service status in first letter. PO-187

AGRICULTURAL ENGINEER wanted to fill position as full-time assistant professor in well-organized eastern college extension service, with principal work in structures and farm safety. A man who can quickly sketch remodeling plans and organize county work is desired. PO-186

ASSOCIATE AGRICULTURAL ENGINEER wanted by New Mexico College of Agriculture and Mechanic Arts for research and teaching relative to irrigation, farm structures, and electricity. Salary depends on qualifications and experience. Write direct to Agricultural Experiment Station, State College, New Mexico.

RANCH MANGER wanted. Dried fruit and general farming on a California farm which is 100 per cent mechanized, 100 per cent irrigated by pipe lines, 100 per cent developed. This is a manufacturing proposition requiring the skill of a thoroughgoing agricultural engineer experienced in western ways of farming. Living conditions, soil type, water conditions, proximity to the city - all of the best. Schools and colleges not far distant. Applicants will please give full statement, including age, education, health, family details, religious convictions, experience in detail, and other information in detail, also a photograph, in the first letter. PO-185

AGRICULTURAL ENGINEERS wanted for temporary and permanent positions in Latin America. Knowledge of Spanish desirable but not mandatory. Experience in the fields of soil conservation, drainage and irrigation. Salary and expense allowances. Write in detail, stating age, experience and when available. Address reply to Box 435, Ben Franklin Station, Washington, D. C.

DRAFTSMAN wanted. Mechanical or structural experience desired. Excellent opportunity for one who can show ability as a designer in the farm equipment and farm structures field. PO-184

AGRICULTURAL ENGINEER wanted by large muck land operator to improve and develop farm machinery for large operations. Good permanent setup for a practical engineer. PO-183

AGRICULTURAL SALES ENGINEER wanted. Applicants will please state age, educational background, practical experience, and send photograph. Also state earnings expected and whether or not presently employed and with whom. A good job for the right party with opportunity for advancement with a fast-growing organization. PO-182

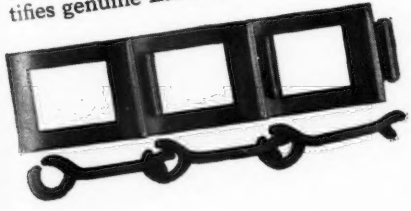
ENGINEERING ACCOUNTANT required by an American firm for Venezuela, who can speak and *(Continued on page 302)*

The Nation's Thanks

TO THE MASSEY-HARRIS "HARVEST BRIGADE"

For Helping to Save America's Grain Crop!

LINK-BELT CHAINS have played an important part in the development of agricultural equipment since the inception of the original Ewart detachable Link-Belt, in 1873. This Trade Mark identifies genuine Link-Belt Chain.



Gathering in the "Miracle Crop" of '44, in the face of an unprecedented manpower shortage, represents a phenomenal achievement. And much credit for its successful accomplishment must go to the Massey-Harris self-propelled Harvest Brigade. The 500 fighting Brigade operators averaged 2039 acres per machine, thus cramming four to five times the normal year's operation into one season!

Link-Belt Company is happy to have supplied a considerable quantity of Silverlink roller chain and steel detachable chain used on the Massey-Harris self-propelled combines in the '44 Brigade. With machines and labor still short in '45, a new Brigade is forming. Again, Link-Belt products will prove their ability to "take it" in the nation's "battle for bread."

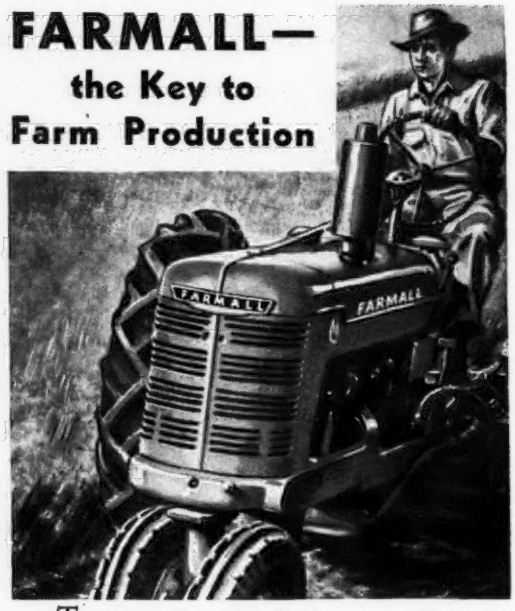
LINK-BELT COMPANY 9998

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices in Principal Cities.

LINK-BELT CHAINS

FOR DRIVES • FOR CONVEYORS • FOR POWER TRANSMISSION

FARMALL—
the Key to Farm Production



Twenty-One Years Ago INTERNATIONAL HARVESTER accelerated the advance of farm mechanization with the introduction of the Farmall Tractor. Farmall was FIRST. Farmall IS first today. Look to Farmall for leadership in the great power-farming developments to come.

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180 North Michigan Avenue — Chicago 1, Illinois

For

Covering Hay Stacks
Sealing Grain Bins
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Every dollar's worth of Sisalkraft gives more value in terms of protection from rain and moisture than any other method or material. Low in cost . . . easy to handle . . . resists tears and punctures. Field-proved on the farm for more than 13 years.

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Manufacturers of SISALKRAFT, FIBREEN, SISAL-T, SISALTAPE AND COPPER-ARMORED SISALKRAFT

EMPLOYMENT BULLETIN

(Continued from page 300)

write Spanish. Experience in earth-moving or grading desirable. Duties include simple construction costs and office management. Position permanent. Norman DeWind, 949 Shoreham Building, Washington, D. C.

ASSISTANT AGRICULTURAL ENGINEER wanted for research in farm structures, equipment, and utilities. Equal division between college of agriculture and agricultural experiment station, including cooperative projects with industry and public utilities. Salary depends upon qualifications and experience. Give full particulars, including military status with application. University of Idaho. PO-181

ASSISTANT AGRICULTURAL ENGINEER wanted for research in hydraulics, irrigation, soil and water conservation. Equal division between college of agriculture and the agricultural experiment station, including cooperative projects with Soil Conservation Service. Salary depends upon qualifications and experience. Give full particulars including military status with applications. University of Idaho. PO-180

DRAFTSMEN wanted. Farm tillage tool experience desired but not essential—otherwise one that can apply himself in this branch of design and development. Location near Chicago, Ill. A real opportunity for a man with ability and vision. PO-179

ASSISTANT EXTENSION AGRICULTURAL ENGINEER wanted by Arkansas Agricultural Extension Service. The phases of work to be handled and the salary will depend primarily upon the training and experience of the applicant. Give brief explanation of training and experience in first letter. Write direct to L. A. Dhonau, State Agent, 524 Post Office Building, Little Rock, Ark.

AGRICULTURAL ENGINEERS, preferably men with some experience in farm equipment, are wanted by a nationally known manufacturer. Experience desired includes design, engineering applications, market research and merchandising. Excellent opportunity for men possessing either limited or broad experience. Salary open. Replies received on a confidential basis. Education, experience and special qualifications should be stated fairly complete in the first letter. PO-178

ENGINEERS AND DRAFTSMEN wanted by well-known manufacturer of farm and garden implements, to develop and design new tools, garden tractors and equipment. Positions permanent. PO-177

AGRICULTURAL ENGINEER wanted. Practical man with sales experience to join large steel company entering farm building field. Dealer sales development program needs men between 28 and 42 with agricultural engineering background and proven sales record in farm equipment, building or similar fields. Excellent opportunity to get in on ground floor of promising postwar industry. Salary. In reply, give complete history of education and business experience as well as references and a small photo. All replies will be held confidential. PO-176

AGRICULTURAL ENGINEER wanted by the Allahabad Agricultural Institute, Allahabad, India, for teaching position. Minimum qualifications, degree in agricultural engineering and some farm experience. Postgraduate degree desirable. Duties would be primarily teaching, but some opportunity to participate in research and extension. Candidate must be active Christian interested in mission work. Discharged veteran with slight handicap eligible, if in good health otherwise. Applicants may correspond with Allahabad Agricultural Institute, 156 Fifth Ave., New York 10, N. Y.

DISTRICT MANAGER wanted for western New York. Experience in the sale of dairy farm equipment helpful, but not essential. Must have automobile. Postwar future. Salary, expense allowance and commission. Thorough field training, during which salary and expenses are paid. Write in detail, stating age, education, experience, and at least three character references. PO-175

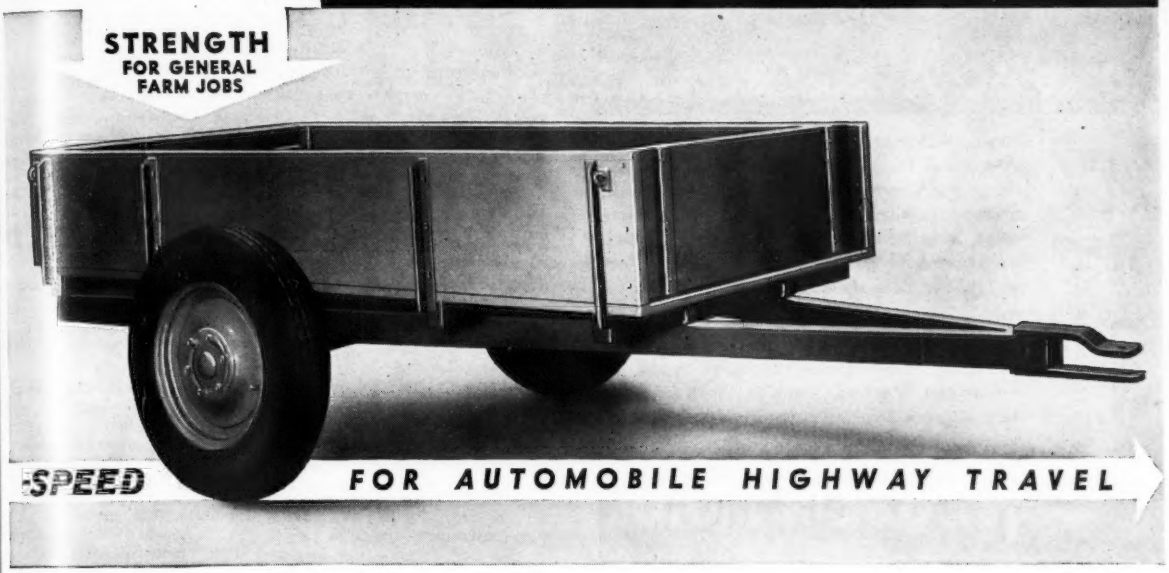
RESEARCH ENGINEER wanted for work in farm structures and rural electrification in a land-grant college in a north central state. A young man is preferred. Salary $3000 or more depending upon qualifications. Write giving full details of education, experience, draft status, and other particulars. PO-174

FACTORY MANAGER with agricultural engineering background wanted to take charge of a small factory producing barn equipment and hay tools. A permanent position for a man with executive ability and one who is interested in research and development. In first letter give full details as to education, experience, family status, age, etc. PO-173 *(Continued on page 304)*

This HARRY FERGUSON, INC.

3/4 TON TWO WHEEL WAGON

is **WHEELED** *by French & Hecht*



A Hundred Uses Throughout the Year

THE disc wheels upon which this sturdy Ferguson Wagon is mounted are designed to take the punishment offered by a wide variety of jobs under as many conditions. IN THE FIELD, hitched to the tractor, it permits quick transport of implements, grain or forage, fencing material, etc. over any ground the tractor can negotiate. ON THE HIGHWAY, hitched to auto or light truck, it permits speedy travel to town and back with whatever is to be carried.

Thus, again, French & Hecht engineers have provided a wheel with the GUTS for heavy work and the SPEED for fast travel.

French & Hecht **ENGINEERS** *can aid you in* **DETERMINING** *the* **JUST RIGHT CAST SPOKE PRESSED WHEELS** *for YOUR* **REQUIREMENTS**

F&H WHEELS ARE IMPORTANT

FRENCH & HECHT, INC.

SUBSIDIARY OF KELSEY-HAYES WHEEL CO.

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Wheel Builders Since 1888

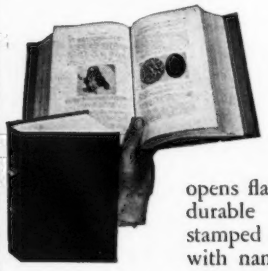
VOLUME PRODUCTION
to meet the
Growing Demands of
War and Industry for
WISCONSIN Air-Cooled ENGINES

Highly systematized, progressive assembly of Wisconsin heavy-duty air-cooled engines keeps them coming off the production line in a steady, uninterrupted stream. Every operation is handled by a thoroughly trained workman who performs his specialized job with speed and skill.

The picture shows a run of Model VE-4, V-type, 4-cylinder engines going through . . . for power destinations on many types of equipment. Perhaps one of these heavy-duty engines has been reserved for service on your equipment.

Most H.P. per pound
WISCONSIN MOTOR
Corporation
MILWAUKEE 14, WISCONSIN, U. S. A.
World's Largest Builders of Heavy-Duty Air-Cooled Engines

A Handsome, Permanent Binder
for AGRICULTURAL ENGINEERING



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Will remit in 10 *days or return binders collect.*

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Consulting Engineering Work In Farm Structures Field
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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

EMPLOYMENT BULLETIN

(Continued from page 302)

SALES ENGINEER wanted for permanent position with small company producing well-accepted building material products. Substantial base salary, better than average proposition for man with liking for sales work and knowledge of building construction. Give full information on past experience and earnings expected. PO-166

AGRICULTURAL ENGINEER wanted by a well-known national organization to engage in sales promotion work on farm buildings, preferably someone in his early thirties with good engineering training and farm background and with plenty of initiative and ingenuity. Special training in farm buildings would be helpful to person selected. Discharged service men will receive special consideration. Write giving full details as to education, experience, etc. PO-164

POSITIONS WANTED

AGRICULTURAL ENGINEER desires employment with either farm machinery or farm buildings construction company; is principally interested in functional design of farm machinery or buildings. Graduate in agricultural engineering from Iowa State College in 1933. Has had 12 years' experience in agricultural engineering work including soil conservation, land surveys, and farm building construction. Is presently managing a large number of farms in Minnesota where tenants are part owners of livestock. Prefers north central states. Age, 35. Married, 3 children. Can give excellent references and employment record. PW-372

AGRICULTURAL ENGINEER, graduate of a midwest state college, desires employment in California. Has several years of design experience with large farm machinery manufacturers as well as general production experience. PW-371

AGRICULTURAL ENGINEER, graduate of Cornell University, with 5 years' experience in college teaching, research and extension; 1 year in research and advertising; 12 years in retail building material sales and service; 3 years scheduling and expediting for WFA, desires position with firm having production, sales or service problems in New York, Pennsylvania, Maryland, or Virginia. PW-370

RESEARCH ENGINEER (electrical-agricultural) is available. Has a bachelor of science degree in electrical engineering (1933) master of science degree in agriculture (1934), professional engineering degree of agricultural engineer (1939), and is now working for a Ph. D. degree; also has engineering license. Temporarily employed as an extension electrical-agricultural engineer on wartime food production problems. Eleven years' experience since earning master's degree; five years in government civil service, and six years in other than government service. Born and reared on a farm. Thirty-four years of age, married, two children. Available at a salary range of from $4000 to $8000 per year. PW-365.

BUY WAR BONDS